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PROMOTION OF THE MECHANIC ARTS.

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EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Committee on Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors or the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

Franklin Institute.

HALL OF THE INSTITUTE, April 18th, 1877.

The stated meeting was called to order at 8 o'clock P. M., the President, Dr. R. E. Rogers, in the chair.

There were present 163 members and 5 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers and reported that at its last meeting 14 persons were elected members of the Institute, and that the Board in compliance with a petition, signed by twenty-five members, has authorized the organization of a Phonetic Shorthand Section of the Institute.

The Actuary also reported the following donations to the library:

The art of projecting, by A. E. Dolbear. Boston, 1877. From J. B. Lippincott & Co.

Pennsylvania archives, 2d ser., by J. B. Lynn and W. H. Egle, M. D. Vol. 2. Harrisburg, 1876. From the Historical Society of Pennsylvania, Philadelphia.

Map of the Middle British Colonies in North America, by T. Pownall, 1876. Map sur la navigation de Terre-Neuve à New York. (Brought to America by Benj. Franklin, 1785.) From T. Hewson Bache.

Catalogue of physical instruments made by N. H. Edgerton, Philadelphia. From the maker.

Report of a reconnaissance from Carroll, Montana Territory, to the Yellowstone National Park and Return, by Wm. Ludlow, 1875. Washington, 1876. From A. A. Humphries, chief of engineers.

The Road: Vols. 1 & 2 in 1 vol. Philad'a, 1877. From T. S. Fernon, Philad'a.

Translated memoir upon the illumination and beaconage of the coast of France, by M. Léonce Regnaud. Wash., 1876. From the Lighthouse Board.

Astronomical and meteorological observations, made during 1874, at U. S. Naval Observatory. Wash., 1877. From the Navy Dep't, Washington.

Annual report of the Lighthouse Board, for 1876. From the Board.

Minutes of proceedings of the Institution of civil engineers; Vol. 47. Session 1876–77, Pt. 1. From the Institution, London.

Twenty-fifth annual report of the board of water commissioners to Common Council of the city of Detroit, etc., for 1876. From D. F. Henry, Chf. Eng.

Annual report of the geological survey of New Jersey, for 1876. Trenton, 1876. Fourth annual report of the New Jersey State board of agriculture, for 1876. Trenton, 1877. From G. H. Cook, Secretary.

Comptes rendus de l'Académie des Sciences, Paris. 6 numbers, 3 indexes and 6 vols. From the Academy.

Annals of the astronomical observatory of Harvard College. Vol. 6–8, 1859–76. From the College.

Speculation concerning molecular physics, by A. J. Stevens. Cambridge, 1877. From the author.

Phonetic Journal, for 1 year, from January 1877. From D. S. Holman.

Illustrated and descriptive catalogue of Locks, Knobs, etc., etc., manufactured by Mallory, Wheeler & Co. Fo. Conn. 1871. From Truman & Shaw.

Annual report of the Committee of management to the members of the Manchester Steam Users' Association. From the Assn.

Annual report of the Chief Signal officer to the Secretary of War, for 1876. From A. J. Myer, Chf. Signal officer.

The Actuary further reported the following Standing Committees of the Board for the current year, as appointed by the President:

(1) *On Instruction.*

J. B. Knight,
Theo. D. Rand,
Pliny E. Chase,
Samuel Sartain,
Washington Jones.

(2) *Elections and Resignations.*

Henry Cartwright,
William Helme,
Charles S. Close,
Cyrus Chambers, Jr.

(3) *Stocks and Finances.*

William Sellers,
Frederick Fraley,
J. Vaughan Merrick,
Enoch Lewis,
William P. Tatham.

(4) *Publications.*

Charles Bullock,
Samuel Sartain,
Joseph M. Wilson,
Pliny E. Chase,
Theo. D. Rand.

(5) *Exhibitions.*

William P. Tatham,
Chas. S. Close,
Coleman Sellers,
J. E. Mitchell,
Frederick Fraley.

(6) *Sections.*

Dr. Isaac Norris, Jr.,
Cyrus Chambers, Jr.,
Henry W. Bartol,
Hector Orr,
C. H. Banes.

The Secretary reported from the Committee on Science and the Arts that at its last meeting it recommended to the Board of Managers the award of the Elliott Cresson Gold Medal to Mr. P. H. Dudley for his Dynograph for measuring railway resistances.

The papers announced for the evening were then read by their respective authors, as follows: one on the manufacture and culture of Flax, by Mr. Hector Orr, and one on the Natural Sciences in Common Schools, by Prof. J. Ennis.

The Secretary presented his report, embracing the following subjects: An illustrated description of the steam street car, built by the Baldwin Locomotive Works, accompanied with an account of its performance during four weeks that it has run on the Market Street line, with amount of coal consumed and other items of cost of running; Mr. Theodore Bergner's Drawing Board, which is provided with a more perfect device than the T square for drawing parallel lines, and not depending on the edges of the board for its accuracy; Mr. N. H. Edgerton's improved projecting lantern and attachments; Mr. E. Strangland's apparatus for steaming grain and vegetables for food for domestic animals; and a new method of folding paper devised by Mr. J. W. Nystrom.

Under the head of deferred business the resolutions of Mr. J. J. Weaver, offered at the last meeting, relative to keeping a list of members out of and desiring employment, were taken up.

Mr. H. Cartwright offered the following as a substitute for both the resolutions of Mr. Weaver:

Resolved, That the Secretary be directed to provide a book in which shall be entered the names, occupations, addresses and references of those members of the Franklin Institute who may report to him as desiring employment, or those needing services of others, which book shall always be open for inspection by members of the Institute; and that all members of the Institute be notified of this arrangement.

On motion, the substitute was adopted.

A letter to the President of the Institute was read from L. M. Haupt, setting forth the advantage to be derived from the continuation of the triangulation of Pennsylvania, as provided for in the Act of Congress approved March 3d, 1871, and requesting the co-operation of the Institute in efforts to procure an appropriation for that purpose by Congress, at the extra session to be convened in June next.

On motion, the officers of the Institute were directed to sign the following memorial:

FRANKLIN INSTITUTE, PHILA., APRIL 18TH, 1877.

Hon. C. P. PATTERSON, Superintendent U. S. Coast Survey,

Sir:—We have learned with regret that the last Congress adjourned without making an appropriation for the continuance of the Triangulation of Pennsylvania.

As such a survey is the basis of all correct information concerning our lines of communication, internal improvements, geological structure, geodetic positions, and, in short, of our general welfare, we have the honor respectfully to request you to urge upon the Congress to be convened in extra session, June 4th next, the importance of supplying the omission by making such an appropriation as will enable the work to be continued through the year.

On motion of Prof. Haupt, it was

Resolved, That it is the desire of the Franklin Institute that the appropriation (requested in the accompanying memorial for the geodetic survey of Pennsylvania) should be made by the extra session of Congress to be convened in June next.

A report was presented from the Phonetic Shorthand Section, showing that, under the authority given by the Board of Managers, the petitioners met on the 13th inst. and organized by electing the following officers: President, E. Alexander Scott; 1st Vice-President, D. S. Holman; 2d Vice-President, M. F. Lobo; Recording Secretary, John Haug; Corresponding Secretary, Franklin E. Page; Treasurer, Jas. A. Kirkpatrick; Conservator, Danl. Carhart; that a committee was appointed to prepare by-laws for the government of the section, and that the necessary qualification for membership in the section is the ability to read phonography in accordance with Pittman's system. The section will meet on the fourth Wednesday of each month.

On motion, the meeting adjourned.

J. B. KNIGHT, *Secretary.*

Planing, Slotting and Shaping Machine.—Messrs. Wm. Sellers & Co. have recently completed, after nearly two years' work, an immense machine combining in one all the movements of planing, slotting and shaping machines. It is arranged with a stroke of 24 ft. when used as a planer, with a stroke of 12 ft. as a slotter, and of 6 ft. as a shaping machine. The motion of the machine in each of its capacities, is independent of the other motions, and is provided with independent hand and automatic feeds in all directions, and automatic stop. All these are controlled by the workman, who is carried on a platform within easy reach of the cutting tool.

The machine was designed to supply a means of dressing work too large to go on ordinary planing machines, such as bed-plates for marine engines, and other large machinery, and differs from other machines designed for the same purpose, in combining with the horizontal and vertical movement in one plane, a horizontal one of 6 ft. at a right angle to the first.

The work to be planed, which may be of any size, is secured to heavy foundation plates alongside of the machine, and remains stationary, and such portions, within a space of 24 ft. by 6 ft. horizontal and 12 ft. high, as require it, can be dressed.

This machine was built to fill an order from the Russian Government, and is to be placed in the navy yard at Cronstadt. An illustration of the machine, with a detailed description, will probably be given hereafter. K.

Continuous Brakes for Railroad Trains.—The great value of continuous brakes for railroad trains has long been appreciated in this country, and scarcely one of our great lines can be found without them on all their passenger trains.

It is only recently, however, that this subject has received the attention it deserves in England, but when once awakened to it the railroad managers with characteristic thoroughness determined to know which is the best, and recently have had two well known systems subjected to a series of tests, the results of which are of the first importance as relating to rapid passenger traffic.

The two systems most favorably known in England, were the Westinghouse Automatic Brake (which was first thoroughly tested and reported upon by the Committee on Science and the Arts of the Franklin Institute on May 20th, 1873,[1] and awarded the Scott Legacy Premium and Medal), and the Smith Vacuum Brake—both American inventions. The former of these had been attached to the more important trains on the Midland Railway, and had already done good service in mitigating the effects of one accident and of preventing another, and the latter had been experimented with to some extent by the Great Northern Railway.

With the view of determining by a thorough test in actual practice which of the two was the better, Mr. D. Dunmore, Locomotive Superintendent of the North British Railway, gave to the representatives of the Westinghouse and Smith brakes, each a train of cars, to be equipped in the most complete manner, to be used in a series of experiments, and in daily work, to settle the question of superiority.

Mr. Dunmore called to his assistance, as a committee to aid in making the tests, the following gentlemen, representing large interests: Mr. Wm. Cowan, Locomotive Sup't of the Great North of Scotland Railway; Mr. Barton Wright, Locomotive Sup't of the Lancaster and Yorkshire Railway; Mr. Haswell, Chief Ass't Locomotive Engineer of the North Eastern Railway, and Mr. Sterling, Local Sup't of the Glasgow and South Western Railway.

The train fitted with the Smith vacuum brake, consisted of a four-wheeled coupled inside cylinder engine, with a two-wheeled Adams bogie under the leading end, and weighing 36 tons, tender weighing 20½ tons; eight carriages, two vans with pumps to assist brakes, and

[1] See Vol. 67—3d Series, page 237.

TABLE SHOWING THE RELATIVE EFFICIENCIES OF WESTINGHOUSE AUTOMATIC AND SMITH VACUUM BRAKES, AT INTERVALS OF 100 FT., FROM MOMENT OF APPLICATION TO STOPPING TRAIN.

Number of Stop.	Train speed in miles per hour when brake was applied.	TRAIN SPEEDS AFTER BRAKE HAS BEEN APPLIED OVER THE FOLLOWING DISTANCES.												Total Distance Run.	Time.	—	REMARKS.
		100 feet.	200 ft.	300 ft.	400 ft.	500 ft.	600 ft.	700 ft.	800 ft.	900 ft.	1000 ft.	1100 ft.	1200 ft.	1300 ft.				
															ft.	sec.		
7	40 +	40 −	38½	37½	34	30	25½	18	.....	.....	.....	.....	.....	.....	800	22½	Smith Vacuum. Glasgow to Edinburgh.	
8	44½	44	43	41½	39	36½	32	28	22½	12½	.....	.....	.....	.....	950	24		
9	45	44½	44½	43	41½	38½	35½	31½	27	21½	11	.....	.....	.....	1020	25½		
10	49½	49½	49	48	46½	43½	41½	38	34	29½	24	16	.....	.....	1170	27½		
12	46½	46½	45½	44	42	39½	37	33	28	22½	14½		.....	.....	1050	26		
13	49	48½	48½	47½	46½	43½	40¾	37½	33½	28½	22½	12½	.....	.....	1138	26½		
2	29½	29½−	27½	23½	17½	.....	.....	.....	.....	.....	.....	.....	.....	.....	480	17½	.....	Diagram shows application of brakes before indicator was started.
5	40	39½	38½	36	32½	27½	22	15	.....	.....	.....	.....	.....	.....	740	20½		
6	40	39½	39½	38½	36½	32½	28	22½	16½	.....	.....	.....	.....	.....	860	23		
7	49½	49½	49	48½	47	44	42	38½	35	30	25	18	.....	.....	1175	26	Smith Vacuum. Edinburgh to Glasgow.	
9	49½+	49½	48½	48	46½	44½	42½	38½	35	31	26	20	.....	.....	1195	27		
11	55 −	54½	54	53	52	50	47½	45	42	38½	35	30½	25	17½	1375	28		
12	54	53½	53½	52½	51½	48½	46½	43	39½	36½	32	26½	18½	8	1310	28		
13	40½	40½−	39½	38	36	32	27	21½	12	.....	.....	.....	.....	.....	830	23		
14	40	39½	39	38	35	31½	26½	20½	10	.....	.....	.....	.....	.....	810	22½		
15	49½+	49½	49½	48½	48	46½	44½	42	38½	35	30½	24	15½	.....	1250	27	.....	Not as promptly put in action as compared with the other stops.
2	30	29	24	16½	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	350	13		
3	30 +	28½	22	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	328	13		
4	40	39½	37	33	25½	16½	.....	.....	.....	.....	.....	.....	.....	.....	550	16		
5	40 +	39½	36½	31½	25½	17	.....	.....	.....	.....	.....	.....	.....	.....	550	16		
6	49½	49½	47½	43½	40	35	28½	21	.....	.....	.....	.....	.....	.....	798	19		
7	50 −	49½	48	43½	38	33½	27½	20	.....	.....	.....	.....	.....	.....	777	18½	Westinghouse Automatic. ... Glasgow ... to Edinburgh.	
8	31	29½	23½	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	345	12½		
9	30	30	26½	20	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	410	14½		Diagram shows increasing speed for 75 ft. Brake not so promptly put in action as compared with other stops.
10	55	53½	52	48	43	39	35	28	20	7	.....	.....	.....	.....	910	21		
12	54	53½	52	48½	44½	40½	36½	30	23	15	.....	.....	.....	.....	952	21		
13	56 −	55	53½	51½	48½	45	41½	38	34½	28½	23	17½	.....	.....	1172	26	.....	Steam kept in engine in working notch.
14	54	53½	52	49	46½	43½	40	37½	32½	28½	22	14	.....	.....	1158	26½	....	Steam on in full stroke.

the experimental van containing recording apparatus; total weight of train 173 tons. Brakes were applied to 54 of the 60 wheels of the train, and 87·88 per cent. of the weight of the train was controlled by the brakes. The train fitted with the Westinghouse brake consisted of an engine exactly similar to the Smith train, tender, nine carriages, one ordinary van, and the experimental brake van, total weight, 166·5 tons; brake blocks applied to fifty of the fifty-six wheels, and 85·75 per cent. of weight controlled by brakes.

The trials were commenced on Tuesday, the 12th of December, but owing to some delay in the preparation on the part of the Vacuum Brake Co., it was postponed to Friday, Dec. 22d, when, everything being in readiness, the trials were proceeded with.

The table taken from *Engineering* gives the results of a number of stops made with each brake, including the successive reductions of speed at intervals of 100 ft. Both brakes were tried on the same day, under similar circumstances, and the same instruments were used in obtaining the results, and with the apparent concurrence of the representatives of both systems.

It will be observed that one great superiority of the Westinghouse brake over the Smith vacuum brake, consists in the promptness with which it is brought into action, and the consequent much shorter distance within which the train is brought to rest.

By observing runs No. 2 of the Smith from Edinburgh to Glasgow, and No. 3 of Westinghouse, it will be seen that the speed of the former at the end of the first 100 ft., after applying the brake, was unchanged, while the latter had reduced the speed from 30 to 28¼ miles per hour, and the distance at which they stopped was 480 and 328 ft., respectively.

This is more marked in the higher speeds, as is seen by comparing runs No. 11 of the vacuum and No. 10 of the Westinghouse, where at 900 ft. the Westinghouse is moving at 7 miles per hour, and is within 10 ft. of stopping, the vacuum train is moving at a speed of 38¼ miles, and has still 475 ft. to go before stopping. K.

Effects of Heat on Voltaic Circuits.—M. W. Hellesen describes numerous arrangements for obtaining very powerful currents, by keeping the liquids around the two plates of an electrolyte at very different temperatures.—*Académie des Sciences; Les Mondes*, Feb. 22, 1877. C.

Hardening of Steel.[1]—By A. Jarolimek (*Dingl. polyt. J.*, ccxxi, 436—446).—It is stated that not only boiling water will harden steel, but that under circumstances, water at a temperature of 150° C. or more will do so, and that boiling hot oil, fluid lead, fluid tin, and even fluid zinc—a cooling liquid of about 400° of heat—will also give similar results. This latter fact is worthy of notice, as it has in general been assumed that steel cannot be hardened unless it be brought down very quickly to a much lower temperature, and that hardened steel softens considerably when exposed to a temperature of 300°; but experiments have shown that the hardness of steel depends upon the quickness with which it is reduced from a temperature of about 500° to one somewhat under 500°. Although the above-mentioned metals are able to harden steel, it was, nevertheless, found that their hardening property could not at all be compared with that of water, this property being in fact influenced not merely by the temperature and the conductivity of the cooling substance, but also by its capacity for heat, its boiling point, and, in the case of a low boiling point, by the amount of latent heat which the vapor contains. For instance, alcohol vaporizes very readily, and as it contains but little latent heat, hardens steel but very badly. Now it is well known that a metal which is heated to a temperature of 1000°, or even only to 500°, must be surrounded by a temperature which renders the existence of water of an ordinary pressure quite impossible. So long as hardened steel possesses this temperature—which it in fact retains until its hardening commences, it cannot be in immediate contact with water, and when plunged into that liquid, must be surrounded by a layer of vapor, which is apt to hold back portions of water near the steel and thus prevent a regular hardening of the latter. It is, of course, improbable that under these circumstances the steel would give up its heat to the water by direct conduction, and as the layer of steam between the metal and the water cannot be superheated to any material extent at so slight a pressure, we must suppose that the water becomes heated by radiation, the layer of water separated by the steel evolving a constant stream of vapor, which condenses on the upper portions of the layer of water. It is shown by calculation that 1 kilo. of steel requires about 0·2 kilo. of water at 20° to lower its temperature from 1000°

[1] Abstracts of Chemical Papers, from the *Journal of the Chemical Society*, for January, 1877.

to 300°; but the reason why a much larger quantity of water is actually required is sufficiently explained, if we consider that (1) the steel has to be moved about in the water; otherwise the formation of vapor would prevent its hardening. (Relying on this fact, it is possible to harden steel under hot water, alcohol, or turpentine.) (2) The vapors condense in the water, and heat a small quantity of it too strongly. Thus it seems that it would be possible to harden steel with a small quantity of water, could the vapor escape as quickly as it is formed. Such, however, is not the case, and the above condensation can, therefore, be facilitated only by the following operations: 1. By plunging the hot steel slowly into the water, the surface of the latter is chiefly acted upon, the vapors having easy access of escape in the air. This method is applicable in cases where the metal above the water remains sufficiently hot to be hardened, *e. g.*, files and other similar articles are easily hardened by this process. 2. A hot and powerful stream of water escaping from a steam-boiler, or an ordinary stream of water, facilitates the hardening by carrying off the vapors as quickly as they are formed. 3. The most satisfactory method is that by which the steel is hardened by means of a thin spray. In this condition the water is largely mixed with air, which, having a very quick and strong action, not only occasions a quick vaporization, but also carries off the vapor formed in a much more complete way than any of the above-mentioned agents. In practice the degree of hardness of steel depends upon the annealing of the latter—a process which always follows the hardening operations. In order to obtain a medium hardness, the steel is cooled slowly throughout the whole of the operation, or it is cooled very quickly to 400°, and afterwards slowly. The former method did not answer in practice, a quick cooling being almost indispensable if satisfactory results are to be obtained. The resulting steel was either of a very hard or of a very soft nature. With regard to the annealing methods, similar experiments were undertaken, the results of which seemed to show that the most profitable form of applying the cooling liquid was when a spray of water was blown on to the steel.

In conclusion, it is stated that fused metals, especially tin, answer very well for hardening small articles. The author was able to harden a steel wire, 3 mm. thick, in a tin bath of 400° of heat, the wire again becoming soft, when it was left in a bath of 350°. On

account of the smaller heat capacity of tin, a large quantity of it is required. One part of steel requires about 45 parts of tin to cool it from 1000° to 300°, if the temperature of the bath before use is 250°, and has not to be raised over 300°.

Glycogenesis.—In the *Annales de Chimie et de Physique*, for July, 1876, Claude Bernard publishes a paper on the formation of sugar-like secretions in animals. He first announced, in his lectures for 1848, that the blood of all animals contains sweet substances, which are secreted by a normal function of the liver, to which he gave the name of the *glycogenic* or *glycogenesic function*. His announcement attracted the attention of many physiologists, who generally sought in the blood the substance from which the sugar is derived. Bernard, on the contrary, found it in the hepatic tissue, demonstrating the fact by showing that after the liver had been carefully washed and freed from all trace of blood, the formation of sugar continued. He subsequently separated a substance which he called *glycogen*, a true animal starch, which E. Pelouze transformed into *xyloidin*, under the influence of fuming nitric acid, and to which he assigned the formula $C_{12}H_{12}O_{12}$. Bernard therefore inferred that both in animals and in vegetables, glucose proceeds from a previous amylaceous substance, and that the formation of sugar in animal livers, after they have been removed from the body, is precisely similar to the same function in a fruit or a tubercule, after it has been separated from a plant. Subsequent investigations showed that the glycogenic function is not confined to the liver, but that it belongs, in a greater or less degree, to many of the tissues, if not to all, and that it is therefore necessary to admit a general glycogeny, instead of a simple hepatic glycogeny. He therefore proposes to investigate a number of special questions bearing on the general issue, such as the formation of sugar in the blood, the formation of glycogenous matter in the liver and in other parts of the body, etc. C.

Temperatures of Combustion.—Berthelot finds that the temperature of combustion of carbonic oxide by oxygen, under constant volume, is comprised between 4000° and 2000°; by air, between 2200° and 1750°. Although his experiments furnish no certain evidence relative to the degree, the nature, or even the existence of dissociation, they seem to establish the possibility of producing real temperatures, in the neighborhood of 3000°.—*Académie des Sciences.*

C.

Boiler Explosions due to Grease and Lime.—A commission, appointed to report on a boiler explosion at La Villette, Paris, attributed it to an insoluble deposit, composed chiefly of a calcareous soap, which formed near the opening of the water feed-pipe, and which was due to the nature of the feed-waters. Some of the water was furnished by the city, containing calcareous matters; some came from condensers, bringing fatty particles from the machines, in which they had been used as lubricants. The commissioners cite numerous accidents which have occurred during the past fifteen years, all of which are attributable to the same source. They, therefore, think it important that all manufacturers should be warned of the danger, and if they are obliged to use such a mixture of waters they should use all possible precautions, such as the purification of the calcareous waters by carbonate of soda; the filtration of the condensed waters, by passing them through wool or felt; the skimming of the grease from the surface of condensing cisterns; and frequent drawings off from the surface of the water in boilers.—*Ann. des Ponts et Chaussées.* C.

Sugar Production in Europe.—The *Journal des Fabricants de Sucre* gives the following table, representing the number of tons of sugar manufactured in Europe, during the past four years:

	1876–7.	1875–6.	1874–5.	1873–4.
Germany,	280,000	346,645	250,708	289,243
France,	225,000	462,259	450,877	396,578
Russia,	250,000	245,000	222,500	202,851
Austria,	150,000	153,922	120,720	167,058
Belgium,	55,000	79,796	71,079	73,516
Holland, etc.,	30,000	30,000	30,000	35,000
	990,000	1,317,622	1,145,884	1,164,246

The editor thinks that the deficiency for the present year will be greater than appears from the estimate in the table, and that it may probably reach 440,000 tons. So large a deficit may, perhaps, lead to still further advances in the price of sugar. C.

Prize to Sir William Thomson.—The Italian Society of Sciences, or the "Society of the Forty," has awarded to Sir William Thomson, professor of the natural sciences in the University of Glasgow, the prize instituted by Carlo Matteucci for the investigator, who, by his writings or his discoveries, has contributed most to the advancement of science.—*Ex.* C.

Silver Refining.—M. Debray states that silver ingots are often found with a fineness of ·998 or ·999, which work badly with those of ·950, giving surfaces with gray spots which can hardly be removed by polishing and which always reappear under gilding. This property is due to the presence of selenium in the sulphuric acid which is made from pyrites, and refiners should, therefore, be very careful in the selection of their acid. As the selenium oxidizes easily, it may be separated by melting the silver precipitated by the copper, in an oxidizing atmosphere, or in the presence of nitrate of potash or soda. —*Ex.* C.

Cometary Spectrum.—On February 16, Father Secchi found the spectrum of Borelly's comet, formed of three bright bands: one in the middle, large and brilliant, in the green; another, narrower and more refrangible, in the blue; a third, still narrower, more difficult to separate and less refrangible.—*Ex.* C.

New Horse-Shoe.—Mr. Yates, of Manchester, has invented a horse-shoe, composed of three thicknesses of cow-hide, compressed into a steel mould, and then subjected to a chemical preparation. It lasts longer, and weighs only one-fourth as much as the common shoe; it never splits the hoof, and has no injurious influence on the foot. It requires no calks; even on asphalt, the horse never slips. It is so elastic that the horse's step is lighter and surer. It adheres so closely to the foot, that neither dust nor water can penetrate between the shoe and the hoof.—*Les Mondes*, March 1, 1877. C.

Water Supply of Turin.—In 1832, Queen Maria Christina, widow of King Carlo Felice, requested Engineer Ignazio Michela, to devise a plan for supplying Turin with wholesome water for the charitable institutions and public fountains. Sig. Michela made a report in 1842, describing six different sources from which a supply could be drawn. In 1847, through the efforts of Count Filiberto di Collobiano, Secretary of the Queen, a commission was appointed with a view to organize a company on a broader basis, to introduce drinking water for the entire population. After examining various plans, two were selected for the final choice; one, to use the subterranean waters between Pianezza and Collegno, by means of deep wells connected by a gallery; the other, to combine the numerous springs in

the valley of the Sangone. For various reasons the preference was given to the latter, although it was estimated that it would cost 300,000 lire[1] more than the other. A company was organized, under a royal decree of April 10, 1853, with a capital of 3,000,000 lr., divided into 6000 shares.

After surmounting numerous obstacles, in the way of proprietary claims, suits against individuals and corporations, and unexpected delays, a reservoir was erected, having a capacity of 4000 cubic metres, with networks of tributary galleries in various directions, and large purchases were made which raised the estimated supply to 200 litres per second, or something more than 16,000 cubic metres per day. From the collecting reservoir the waters were carried by a well-cemented vaulted gallery in the subsoil at a mean depth of 3 metres to the "Baraccone," at the side of the highway to Rivoli. The gallery was 1 metre wide, 1·75 m. high, 12,290 m. long, with a declivity of 4·2 ft. per mile, interrupted only by iron siphons for the passage of streams, canals or depressions. From the Baraccone reservoir the water is led in a tube of 45 centimetres internal diameter, 7300 metres into the city, and 9604 metres to its discharge into the Po. The level of the water, at its entrance into the tube, is 45 m. above the ground-surface, at its arrival in the Via di Doragrossa at Porta Susa.

On March 6, 1859, the works were publicly inaugurated by the opening, on the Square "Carlo Felice," of a magnificent fountain, which threw a jet of 38 metres. By means of a loan of 1,200,000 lr., contracted under the guarantee of the Municipality, the company extended its main and tributary galleries and built a filtering reservoir, thus increasing the supply and the conveniences of distribution. It was under obligations to supply the city authorities with 25 litres per second, at the rate of 3 centesimi[11] per cubic metre, and to limit the rate for private citizens to 23 centes., which was reduced, by discounts and concessions, to an average rate of 17 centes. The great superiority of the water over that of the wells, was speedily recognized, and its use rapidly extended, in cafés, inns and private houses. The efficacy for extinguishing fires, through the force consequent on the great head, multiplied the number of fire-plugs under

[1] The Italian *lira* is equivalent to the French *franc*.

[11] A *Centesimo* is equivalent to 2 mills.

the care of the government, the city, the insurance companies, and private citizens. Thus the company's revenue, which was 12,435 lr. in 1859, reached 279,000 lr. in 1875, and the service-pipes, at the end of 1873, aggregated 53,000 metres.

Notwithstanding the new sources of supply which the company from time to time acquired, an extraordinary drought in the year 1861, showed that the demand had already exceeded the permanent supply. The drought continuing, in varying degrees, through the eleven subsequent years, it was soon found that none of the original estimates were trustworthy, and that there were grave doubts whether the company would be able to carry out its existing contracts, to say nothing of the new ones for which it was continually solicited. In 1867, Sig. Claudo Calandra, from whose memoir the present account is abridged, accompanied by other engineers who were officially or temporarily connected with the company, began a series of geological explorations of the neighboring districts. New excavations and galleries were consequently decided upon and let out to contractors, who began operations in the latter part of summer, 1872. The new works were twice destroyed by extraordinary inundations of the Sangone, but the "proverbial Piedmontese firmness and obstinacy" prevailed over all obstacles, and by tapping new water-sheets, an actual supply of 100 litres per second was secured, but one-fourth was lost by overflow, leakage, and unknown causes of waste. All immediate apprehensions of a water famine are removed, but the growth of the city, the creation of vast vegetable and flower-gardens, the growing demands of public cleanliness, the rapid multiplication of baths, dye-houses and laundries, will soon require a still further and more radical enlargement of the regular stated service.—*Il Politecnico*, xxv, Nos. 1 and 2. C.

Book Notices.

ELEMENTS OF GEOMETRY. By G. M. Searle, C.S.P. 8vo, pp. 135. New York, J. Wiley & Sons.

The author's desire is to reduce the number of axioms to a minimum, and to introduce a new method of treatment for the subject of parallels. Other modifications are also noted. Definitions are reserved until needed, which is an improvement on the old methods. The chapter on proportion is omitted. The theory of the formation

of bodies by the continuous motion of points, lines and surfaces leading directly to fluxions, is also an improvement, but we cannot commend the apparent ambiguity existing in some of the theorems (Prop. 13, p. 11; Prop. 26, p. 19), nor the change produced in familiar and almost stereotyped propositions by the desire to produce something original. Moreover, most mathematical writers have agreed to call the circumference the bounding *line* of the *area* called the circle; by assuming to reverse the order, it leads to confusion from the very inception of the science, and leaves the bounding line nameless.

Segment and sector are always understood to mean areas, and so they are used here, yet the author defines them as parts "of a circle," etc.; now, if a circle be a *line*, as he determines to call it, how can the sector (an *area*) be a part of it? The word circle must always have, in this treatise, a double meaning—and hence be ambiguous. The idea of a plane, generated by one line, revolving about another to which it is perpendicular, limits it to a *circle*—a particular form of a more general class of figures.

The entire work, including a good collection of problems and an appendix, is compact and well printed, and we think will be enjoyed by mathematicians generally. H.

TEXT-BOOK OF MINERALOGY. By Prof. Edward S. Dana. 8vo., pp. 485. New York, Wiley & Sons.

This long expected work, begun years ago by Prof. J. D. Dana, supplies the great need of a text-book of mineralogy for schools and colleges. In the last edition of Prof. J. D. Dana's mineralogy, the descriptive portion, synonyms, etc., were made full and complete, so much so as to make that book the standard, not only of this country, but almost of the world. The space required to do this as thoroughly as it was done, prevented full justice to any other department; this want is now supplied. The book is written concisely, but clearly, and conveys much information in few words. The descriptions of all the more common minerals, while necessarily briefer than those of the larger work, are sufficient. The rarer species are enumerated and a brief description given. One very valuable feature has been introduced: a brief summary of the easily detected differences between the mineral under description and those which it most resembles.

We notice that the recent discoveries, chiefly in our own state, in regard to the mineral damourite, which are among the most remarkable of recent discoveries in the science, appear to have been overlooked. There are other minor omissions, but they detract but little from the value of the book for the purpose designed. R.

Civil and Mechanical Engineering.

CERTAIN POINTS IN THE DEVELOPMENT AND PRACTICE OF MODERN AMERICAN LOCOMOTIVE ENGINEERING.

By Francis E. Galloupe, S. B.

[Continued from Vol. ciii, page 264.]

Now this is diminished by the volume of the internal staying, and, although it was supposed that this would be inconsiderable, a correction was made for this. The arrangement of these stays caused the quantities by which the capacity was to be corrected, to be of two kinds. First, a constant correction for every depth, consisting of the volume of the perpendicular parts, the upright sheet-iron stays and rods, which amounted to 1379·62 cu. in. = ·795 cu. ft. = 5·94 gallons; and second, a part, consisting of the angle iron two inches high, running around the bottom edge of the tank, and the angle iron and horizontal stay rods which were found to be at a height of $22\frac{1}{8}$ inches above the bottom. This amounted to 919 cu. in. = ·532 cu. ft. and $\frac{\cdot 532}{2}$ (= ·266) × 7·4805 = 1·9898 gallons per inch of height, or 1·9898 × 4 = 7·9529 gallons in all. The ultimate correction was therefore 13·906 gallons, and the real capacity 2502·3836 gallons.

This process was gone through four times, and the capacities found were as follows:—1st trial, 2453·23 gallons; 2d trial, 2519·44 gallons; 3d trial, 2465·57 gallons; and 4th trial, 2502·38 gallons, the variations depending on very slight differences indeed, in the measurements and decimal places.

Incidentally, the weight of the water contained in the tender when full may be here stated. It amounted to
336·3799 cu. ft. × 62·4 = 20,990 lbs. or 10·495 tons.

Now, in order to calculate columns 16 and 17, the cubic feet of water corresponding to each inch of height of tank were obtained. Multiplying the area 94·1743 sq. ft. by ·0833 ft. (= 1 inch) we

obtain 7·8445 cubic feet of water in the tender for each inch of height when uncorrected for the staying and angle iron. For the corrected capacity we have 7·8445 — ·266 cu. ft. = 7·5785 cu. ft. This is to be used only for the first two inches at the bottom and for from 21⅛ to 23⅛ inches depth. Table VII gives the depths of water taken, and the coefficients by which these two columns have been obtained.

It shows the water and coal consumption during all the trips, and also the relative amounts used on the same portions of the road on different days. Now, on Wednesday, it seems, 26 inches depth of water were consumed in carrying the train from Boston to Ipswich. Therefore, there are 26 — 2 = 24 inches to be multiplied by 7·8445 cu. ft., or 188·2680 cu. ft. Now, the other two inches lying between 21⅛ and 23⅛, are to be multiplied by the corrected capacity per inch of depth, which gives 2 × 7·5785 = 15·1570. Or, the total number of cubic feet of water consumed in running 27 miles is
188·268 + 15·157 = 203·425, and this is the first number given in column 5.

Now, the number of cubic feet of water consumed between the stations, column 16 (of Tables I-VI), is calculated *on the supposition that the rate of evaporation is proportional to the coal burned*, and in this case, the amount of coal was 1323·1 lbs. Hence,
203·425 ÷ 1323·1 = ·154 cubic ft., the average amount consumed per lb. of coal; and multiplying this coefficient by the number of pounds of coal burned between the stations, respectively, the results given in column 16, were obtained; and those in column 17, by dividing those in column 16, by the number of miles between the stations, respectively, and multiplying by 62·4, the weight of a cubic foot of water.

It will be seen that these coefficients and averages vary greatly on different parts of the road and on different days.

The depths taken at Newburyport and Salem, where no water was taken on, serve simply as checks. For instance, on Thursday, between Ipswich and Portsmouth, a distance of 29 miles, 15¼ inches of water were used, or ·54 inch per mile. Now, Newburyport being 10 miles from Ipswich, we might expect that there would be used in going that distance, 10 × ·54 = 5·4 inches, leaving
42·75 — 5·4 = 37·35 inches in the tank. But, by the record, it seems that there were actually but 36 inches at Newburyport, which

TABLE VI.—Trip No. 6.

DATA AND RESULTS FROM HINKLEY ENGINE No. 55, EASTERN R. R., ON BANGOR TRAIN, RETURN TRIP.

Date: Friday, March 17th, 1876.
Day: Weather, wet and icy.—Wind, E.

At Portsmouth: *Coal taken on, none.* *Depth Water in Tender at starting, 41½ inches.* *Number of Cars, 7.*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			Time Record.			Coal Record.			Speed Record.						Water and Steam Record.		
Miles from Portsmouth.	Train Due. Time.	Station.	Train Arrivals and Leavings. Corrected time by watch.	Length of Stop.	Steam Pressure. Gauge Readings.	Weight fired between stations.	Aggregate weight.	Pounds of coal consumed per mile run.	Cut-off. Inches of stroke.	Steam Pressure at time of observing speed.	Revolutions per minute.	Feet per minute.	Max. Rate observed. Miles per hour.	Average Rate. Miles per hour.	Cubic Ft. of Water consumed between stations.	Weight of water or steam consumed per mile	NOTES. Oiling, Shutting Off, Braking, Stirring Fire, Air Brake Pressure, etc.
	H. M.	Leave	H. M. S.	M. S.	LBS.	LBS.	LBS.			LBS.						LBS.	
	A. M.		A. M.														
	11 18	Portsmouth	11 24 25		135	47·3 418·5	465·8		10 10	127 109	126 270	2061 4418	23·4† 50·2†		48·909		Valve began to blow off at 140 lbs. † Very heavy up-grade. Time, 11.26.00.
									10	113	240	3927	44·6†	29·5		610·4	† Up-grade. Time, 11.31.00. † Time, 11.32.00. Shook grate.
5	11 28	*Greenland	11 34 35		122	148·5	614·3	93	14						15·593		At Portsmouth 31 shovelfuls put in. Weather clearing off.
			ar. 40 25						10	108	150	2484	28·3†	20·6		455·3	† At stone overhead bridge. Time, 11.37.00
7	11 35	North Hampton	11 40 45	20	115	94·5	708·8	74	10	106	250	4090	46·5†	31·9	9·923	206·4	Oiled cylinders. [a down-grade.
									14	104	110	1800	29·5†				† Time, 11.39.00. Partly on an up-grade and over a ridge upon
10	11 42	Hampton	11 46 25	...	110	121·5	830·3	32	10						12·758		† Heavy up-grade. Time, 11.43.00. Stirred fire.
									10	103	250	4090	46·5†	26·1		265·3	† Time, 11.49.00.
13	11 47	*Hampton Falls	11 53 20		108	189·0	1019·3	41	10	98	250	4090	46·5†		19·845		† Time, 11.50.00.
									10	102	130	2127	24·2†	33·9		309·5	† Very heavy up grade. Time, 11.57.00.
14	11 50	*Seabrook	... ...		.....	.....			.....	.....	.....	.....	.....		.....		No stop made. Stirred fire.
	P. M.		P. M.														
17	P. M.	*Salisbury	12 00 25		103	40·5	1059·8	47	6						4·253		No stop. Weather, cloudy but dry.
			ar. 04 15		.....				.....	.....	.....	.....	.....	31·3		132·7	At Newburyport, depth water in tender, 28 in.
19	12 05	Newburyport	12 06 40	2 25	138	60·8	1120·6	20							6·384		Oiled cylinders.
			... ...		.....												
		Know-nothing	12 09 55	...	136	20·3	1140·9		.....	.....	.....	.....	.....	24·8	2·132	177·2	
22		*Knight's Crossing	12 13 55		120	108·0	1248·9	27	6						11·340		Stirred fire. Cylinder cocks opened.
			... ...		.....				6	109	200	3273	37·2†	38·3		176·9	† Time, 12.17.00. Taken on the up-grade to cut.
26		*Rowley	12 20 10	...	120	108·0	1356·9	27	10						11·340		Cylinder cocks opened. Made a stop
			ar. 26 40		.....				10	120	200	3273	37·2†	27·7		235·9	† Time, 12.24.00. Register in fire-door open.
29	12 28	Ipswich	12 32 40	6 00	138	216·0	1572·9	36	10						29·808		Foggy. Stirred fire [41¼ in.
			ar. 42 50		.....				10	99	220	3600	40·9†	29·5		371·9	At Ipswich: Depth water, before filling, 23¾ in.; after filling,
34	12 40	Wenham	12 44 05	1 15	123	74·3	1647·2	43	10	113	170	2781	31·6†		10·253		† Time, 12.39. Began to snow. Very heavy up-grade, time, 12.47.
									10	106	200	3273	37·2†	28·8		319·9	† Time, 12.48.00. Oiled cylinders from cab. [¼ m. Stirred fire.
36		*North Beverly	12 48 15		106	27·0	1674·2	37	6	113	360	5891	67·0†		3·726		† Time, 12.50.15. This is partly estimated Counted 90 revs. in
			ar. 52 30		.....				6	113	300	4909	55·8†	28·1		116·3	† Taken immediately after the preceding.
38	12 48	Beverly	12 53 25	55	122	81·0	1755·2	14							11·178		Counted 150 revs. in ½ minute
			ar. 56 45		.....				.....	.....	.....	.....	.....				Snowing very fast.
		Know-nothing	12 57 00	15	121	33·8	1789·0							18·2	4·684	494·2	Oiled engine outside.
			ar. 00 00		.....												† Blew off at 139 lbs., pressure suddenly rising to 141 lbs.
40	12 58	Salem	1 01 50	1 50	139†	270 0	2059 0	57	10						37·260		
									10	121	170	2781	31·6†	30·5		581·3	† Time, 1.06.00. Up-grade, though not very heavy.
44		Swampscott	1 09 40		102	00·0		68	10						.....	.....	
			ar. 12 20		112				10	104	120	1963	24·1†	22·5			† Time, 1.11.00.
45	1 11	Lynn	1 13 30	1 10	129	40·5	2099·5	00	10						5·589		Stirred fire. Oiled cylinders.
									10	.....	70	1145	13·0†	23·2		348·8	† Time, 1.16.00.
46		West Lynn	1 18 05		123	87·8	2187·3	41	10						12·116		Stirred fire.
									6	116	200	3273	37·2†				† Time, 1.19.00.
		Oak Island	1 20 45		111	27·0	2214·3		6					31·3	3·726	247·1	
50		Revere	1 23 45		108	27·0	2241·3	29	6						3·726		
			... ...		.....				6	107	200	3273	37·2†	15·7		232·5	† Time, 1.25.30.
51	1 28	Chelsea	1 27 35	...	120	47·3	2288·6	27	10						6·527		Stirred fire.
									10	112	160	2618	29·8†	31·3		203·6	† Time, 1.31.00.
53		Everett	1 31 25		111	60·8	2349 4	24							8·390		
		Curve at Somerville	1 33 25		106	13·5	2362·9		17					19·5	1·863	639·8	Slowed down for draw.
			ar. 34 30														
54		Somerville	1 34 50	20	116	00·0		74	17						.....		Rate of speed, about 250 revs. per minute.
		B. & M. R. R. Crossing															
			† 37 30		113												
		Prison Point	1 41 50	4 20	133	00·0		00						12·9†		.....	† Delayed at Prison Point by a freight train on the Fitchburg R. R. Crossing.
							Tot. for 56 miles run.								.....	.....	At Boston.—Watch 50 secs fast at 1.48 P. M. Estimated coal left in tender, 2 tubs.
		Arrive at							.....	.....	.....	.....	.....			.....	
56	1 45	Boston	1 44 10		.....		Av. lb. coal — per mile, 38	00									Depth water in tender on arrival, 23½ inches.
					Average steam pressure, 119 lb.									Average, 28·5		Average, 322·4	

* Flag Stations.

* Maximum speed observed during all the trips.

TABLE VII.—Water Record.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Miles.	Watering Stations.	Wednesday, March 15th. Tables I & II.					Thursday, March 16th. Tables III & IV.					Friday, March 17th. Tables V & VI.				
		Depths Taken	Difference.	Cubic Feet Water Consumed.	Pounds of Coal Consumed.	Cu. ft. per lb. of Coal.	Depths Taken.	Difference.	Cubic Feet Water Consumed.	Pounds of Coal Consumed.	Cu. ft. per lb. of Coal.	Depths Taken.	Difference.	Cubic Feet Water Consumed.	Pounds of Coal Consumed.	Cu. ft. per lb. of Coal.
		IN.					IN.					IN.				
	Boston	42	26	203·425	1323·1	·154	40	20	156·358	924·8	·169	41	15	117·608	1531·3	·077
27		16					20					26				
	Ipswich	41⅛					42¾					41				
	(Newburyport)	.....	10¼	80·496	1410·8	·057	36	15¾	123·550	909·0	·124	34¾	20	156·358	1525·6	·103
29		31¼					57					21				
	Portsmouth	40¼					42					41½				
	(Newburyport)	.....	23	179·892	1640·3	·109	30¾	17½	137·279	1005·8	·136	28	18¼	142·996	1356·9	·105
20		17¼					24½					23¼				
	Ipswich	42					42					41¼				
	(Salem)	.....	16¾	146·918	951·6	·157	33¾	16	125·512	864·0	·145	.....	17¾	139·140	1006·0	·138
27							26					23½				
	Boston	23¼														

shows that the consumption was not strictly proportional to the distance run.

We cannot discuss, in full, the facts relating to the water consumption indicated by these figures, but a single example will suffice. Let us consider the water consumption in running the train from Boston to Portsmouth on Thursday. The volume of one cylinder is 4825·497 cubic inches, or 2·792 cubic feet, and the cylinder capacity, equal to the steam required per revolution, 11·168 cubic feet. The average steam pressure for the trip was 131 lbs., and the weight of a cubic foot of steam under this pressure, being ·32592,[1] that required per revolution would be $11·168 \times ·32592 = 3·64$ lbs. Now, the circumference of the wheels being 16·36 feet, $5280 \div 16·36 = 322·27$ revolutions would be made, if there was no slip, in a mile, and there would be required $322·27 \times 3·64 = 1173·06$ lbs., or $\frac{5}{12}$ of this, equal to 488·775 lbs. of steam per mile when cutting off at the usual point, 10 inches of the stroke. Now, it appears, by column 17, that in but one case was this great amount actually used, the average being but 364·1. To make this difference more plain, for the 56 miles there would apparently be required $488·8 \times 56 = 27,372·8$ lbs. of water. On the other hand, by the table, we know it to be a fact that but $156·358 + 123·55 = 279·9$ cubic ft. or 17,465·76 lbs. were used. If we attempt to explain this by the reduction of pressure in the cylinder, assuming it to be 20 lbs. less, or 111 lbs., the weight of a cubic foot of steam would then be but ·28625, or $·28625 \div ·32592 = ·878$ that in the former case, and the apparent consumption would be 24,033 lbs. It seems that the whole tendency is also to increase rather than diminish this difference; the air brake was working most of the time, any slipping of the wheels would increase it because the valve would open oftener, and still more would be lost through the safety valves, the blower, leakage of all sorts, and the use of the injector. The only cause I can assign for it, unless the point of cut-off was at any time less, or excessive reduction of pressure in the cylinder by wire drawing occurred, is the saving of steam on down grades, and that due to the distance traveled by reason of the momentum of the train, after the steam was shut off on approaching stations. The amount of water in the boiler was kept pretty constant during all parts of the trip.

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[1] Porter.

Another point to be noticed is the great apparent evaporative power and efficiency indicated. The average evaporation for all the trips is ·123 cubic ft., or 7·6752 lbs. of water per lb. of coal, which gives an apparent boiler efficiency of $e = \frac{E'}{E} = \frac{7{\cdot}675}{10{\cdot}92} =$ over 70 per cent., while we have found its maximum real efficiency to be probably not more than ·557. This probably shows that there was 14 or 15 per cent. priming.

In the column of notes there are a number of facts in regard to the manner of stopping the engine, the air-brake pressure, and time required to stop the train from full speed.

In order to be certain that the engine which has been selected was not exceptional in any of the conditions under which it worked, similar data have been taken from the Mason engine No. 36, on three Rockport trips, but they have not yet been worked out. The accompanying record (Table VIII) of the performance of eight of the best engines upon the Eastern Railroad, this one included, for the month of January, 1876, will answer the same purpose.

Before we leave this subject, the discussion of the tables would be incomplete if no allusion were made to the power exerted by this locomotive, and for the purpose of investigating this let us select the data furnished in Table II, on the return trip, Wednesday, and the straight and level piece of track, four miles in length, between West Lynn and Revere. Although the term, horse power, is applicable to stationary rather than locomotive engines, since, as a general distinction, the office of the latter is to draw a load rather than to lift a weight through a certain height, its power can be reduced to an equivalent horse power, and this is equal to the product of a certain weight attached by a rope to the circumference of one of the driving wheels, into a certain height through which it is lifted, per minute, divided by 33,000. Since the power exerted is equal to the gross work performed, it may be represented, calculated from the effective steam pressure and the speed, as follows:—

$H.P. = \frac{p \times 2 \times A \times 2 \times S \times N}{33{,}000} = \frac{4pASN}{33{,}000}$. It therefore depends upon the effective pressure, p, per square inch, exerted through the whole stroke; the joint area, $2A$, of the two pistons; the length of stroke, S, in feet; and the number of revolutions, N, per minute. Now, the average speed, by the table, is seen to have

TABLE VIII.

PERFORMANCE OF ENGINES OF THE EASTERN RAILROAD COMPANY. MONTH OF JANUARY, 1876.

Number of Engine.	NAME.	Where Made.	Size of Cylinder.	Kind of Service.	Miles Run.	COAL.			WOOD.		OIL.		WASTE.	
						Tons.	Pounds.	Miles run to one ton of Coal.	Cords.	Miles run to one cord of Wood.	Pints.	Miles run to one pint of Oil.	Pounds.	Miles run to one pound of Waste.
27	"Chelsea."	Hinkley	16 x 24	Pass.	549	11	960	50	½		32	17	11	50
51	"Everett."	"	16 x 24	Freight	2284	55	300	42	1⅛		108	21	55	42
52	"Bangor."	R. I. Works	16 x 24	Pass.	1992	32	1960	60	1		118	17	50	36
55	No name	Hinkley	16 x 24	Pass.	3016	53	1280	56	1		182	17	55	55
56	"St. Lawrence."		13 x 20	Pass.	2382	30	1200	77	1½		156	15	33	72
58	"Massachusetts."	Hinkley	16 x 24	Freight	2063	42	2220	48	1½		124	17	53	39
60	"America."	R. I. Works	16 x 24	Pass.	2704	56	2160	47	¾		168	16	55	49
75	No name	E. R. R. Works	17 x 24	Pass.	2802	46	2160	60			152	18	44	64

TOTALS AND AVERAGES

FOR 90 LOCOMOTIVES ON THE EASTERN RAILROAD FOR THE MONTH OF JANUARY, 1876.

	Average.		Average.
Cost of Coal per Ton,	$6.00;	per mile run,	10·5 cents.
" Wood per Cord,	5.12;	" "	17·6 "
" Oil per Pint,	.09⅛.		
" Waste per Pound,	.08¼.		

	Total.	Miles run to	Average.
Tons of Coal used,	$2,233\frac{2039}{2240}$;	One Ton of Coal,	57
Cords of Wood used,	1,050;	One Cord of Wood,	29
Pints of Oil used,	8,677;	One Pint of Oil,	18
Pounds of Waste used,	3,078;	One Pound of Waste,	50

been 30·5 miles per hour. Let us call it 30. In a mile without slip, the wheels would make

$\frac{5280}{16{\cdot}36} = 322{\cdot}7$ turns, or $N = \frac{30}{60} \times 322{\cdot}7 = 161$ revolutions per minute. Let us at first assume the boiler pressure at its maximum of 140 lbs., and let it be reduced 20 lbs. in its transmission to the cylinder. Let it further be assumed that the pressure of 120 lbs., or 134·7 lbs. absolute, continues constant to the point of cut-off at 10 inches of the stroke. The ratio of expansion will hence be $\frac{24}{10} = 2{\cdot}4$, the hyperbolic logarithm of which is ·8754. Dividing this log. + 1, by 2·4, we obtain ·781 by which to multiply the mean absolute pressure, 134·7 lbs., during admission. This gives 105·2 lbs. for the mean absolute pressure during the stroke, or 90·5 lbs. for the mean effective pressure, p. Hence there will be 201 (sq. in. area) $\times$ 90·5 = 18,190·5 lbs. pressure constantly exerted upon each piston, or the entire pressure, P = 36,381 lbs. The space through which this acts per revolution is 2 $\times$ the stroke of 2 feet, and multiplying this by the number of revolutions, N = 161, we obtain 23,429,364 foot-pounds of work that this engine can perform per minute under these conditions. The equivalent horse power is therefore $\frac{23{,}429{,}364}{33{,}000} = 710$ *H. P.*

The Tractive Power of an engine is limited by the amount of adhesion of its coupled wheels to the rails. The weights of the principal parts of this engine, which determine its amount, and also those of the tender and train which it was drawing at this time, are as follows:—

Driving Wheel Centres, 4 @ 1480 lbs., .	5,920 lbs.	
Frame, ...	3,200 "	
Boiler, with tubes, empty, . .	9,800 "	
Water in boiler to 2d gauge (50 cubic feet), ...	3,120 "	
Weight on the Driving Wheels, .	40,540 "	
Weight on the Truck, . . .	23,800 "	
Weight of Engine alone, in working condition, with two gauges of water, .	64,340 lbs.	= 32·17 tons.
Tender, empty, . . .	20,000 "	= 10· "

Water contained in Tender, .	20,990 lbs.	= 10·5	tons.
Coal contained in Tender, . .	6,000 "	= 3·	"
Tender with water and coal, .	46,990 "	= 23·5	"
Maximum weight of Engine and Tender,	111,330 "	= 55·7	"
Average weight of coal and water in Tender, = $\frac{2}{3}$ maximum, . . .	17,994 "	= 8	"
Average weight of Tender with water and coal, ...	37,994 "	= 19	"
Total weight of Engine and Tender with average load, . . .	102,334 "	= 51·2	"
Weight of Train, 7 cars with average load @ 22 tons apiece, . . .	308,000 "	= 154	"
Total average weight of Engine, Tender and Train, ...	410,334 "	= 205·2	"

The friction of the driving wheels upon the rails, or the adhesive weight, is usually taken at $\frac{1}{5}$ the weight resting upon them, or, in this case it would be 8108 lbs. According to Weissenborn's "American Locomotive Engineering," the number of lbs. adhesive weight per ton of load on the driving wheels varies with the condition of the rails and weather as follows:—with dry rails, 600 lbs. per ton; wet rails, 550; damp, 450; foggy weather, 300; and ice or snow on the rails, 200. In this case the rails were dry and the corresponding adhesion which could not be exceeded by the tractive force, $= 20{\cdot}27 \times 600 = 12{,}162$ lbs. The tractive power is found by dividing the foot-pounds exerted per revolution by the circumference of the wheel. By the table the actual steam pressure was 98 lbs. Subtracting 20 lbs., we find, in the same manner as before, that the mean effective pressure is but 57·7 lbs., the foot pounds of energy developed per revolution but 92,780, and the ultimate horse power that could be exerted under these conditions, 452 H. P. The tractive power, or force exerted to move the engine with its train one foot is therefore $T = \frac{2\,p\,A{\cdot}2\,S}{2\,\pi\,R} = \frac{92{,}780}{16{\cdot}36} = 5671$ lbs.

To conclude the discussion of these data I have made a table of summaries (Table IX) which will be briefly described.

Column 5 = differences of col. 4.

Column 9 = col. 8 × 13·5 lbs., weight of one shovelful of coal.

TABLE

Synoptical Tabl

1	2	3	4			5			6	7		8	9	10	11	12	13	14	15	16	17
			Time Record.									Coal Record.						Water and Steam Record.			
Trip.	Date.	Terminal Stations.	Time of leaving Stations.			Duration of Trips.			Number of Stops.	Total Duration of Stops observed.		Number shovelfuls fired between termini.	Pounds consumed per trip of 56 miles.	Av. pounds consumed per mile run.	Miles run per ton of coal.	Av. pounds of coal consumed per minute.	Mean rate of combustion.	Depths used.	Equivalent cubic feet.	Av. cubic feet per mile run.	Av. cubic feet consumed per pound of coal.
			H.	M.	S.	H.	M.	S.		M.	S.							IN.			
	1876.	Boston.....	8	30	34																
1	Wednesday..	Portsmouth.	11	01	00	2	30	26	13	7	40	202½	2,734	56	40	18·1	73·2	36½	283·83	5·07	·1055
		Portsmouth.	11	26	35																
2	March 15....	Boston.....	1	49	15	2	22	40	13	11	35	190½	2,572	55	43	18·0	72·6	41¾	326·81	5·83	·1330
		Boston.....	8	31	00																
3	Thursday....	Portsmouth.	10	57	45	2	26	45	14	13	65	142½	1,924	41	58	13·1	52·9	35¾	279·91	4·99	·1475
		Portsmouth.	11	22	45																
4	March 16....	Boston.....	1	42	25	2	19	40	15	16	15	138½	1,870	34	60	13·4	54·2	33½	262·79	4·69	·1403
		Boston.....	8	31	20																
5	Friday.....	Portsmouth.	10	56	40	2	25	20	15	14	55	226½	3,057	64	37	21·0	84·6	35	274·03	4·89	·0898
		Portsmouth.	11	24	25																
6	March 17....	Boston.....	1	44	10	2	19	45	14	18	50	175	2,363	38	47	16·9	68·4	36	282·14	5·04	·1215
	Total Averages and Aggregates.....					2	24	06		Ag. 82	20		Ag. 14,520	48		16·8	67·7		Ag. 1709·51	5·09	·1229

Number of trips, 6.

Miles per trip, 56.

Total number miles run, 336.

Times, { Total duration of trials, 15 hrs. 42 m. 55 secs.
Time running, 13 hrs. 2 m. 15 secs.
Time not running, 2 hrs. 40 m. 40 secs.

Total average load, 205 tons.

Capacity of each cylinder, 4,824 cu. in. = 2

Area each piston, 201 sq. in.

TABLE IX.

Synoptical Table of Results.

10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	2
Record.				Water and Steam Record.				Steam Pressure.		Record of S						
Av. pounds consumed per mile run.	Miles run per ton of coal.	Av. pounds of coal consumed per minute.	Mean rate of combustion.	Depths used. IN.	Equivalent cubic feet.	Av. cubic feet per mile run.	Av. cubic feet consumed per pound of coal.	Number of observations of Gauge.	Av. of Gauge Readings. LBS.	Max. speed observed. Revolutions per minute.	Max. speed observed. Feet per minute.	Max. piston speed obs'd. Feet per minute.	Max. speed observed. Miles per hour.	Steam pressure at time of observing speed. LBS.	Cut-o Adm'n—in. of stroke.	
56	40	18·1	73·2	36¼	283·83	5·07	·1055	25	127	240	3927	960	44·6	114	10	
55	43	18·0	72·6	41½	326·81	5·83	·1330	29	115	240	3927	960	44·6	104	10	
41	58	13·1	52·9	35¾	279·91	4·99	·1475	33	131	260	4255	1040	48·4	128	8	
34	60	13·4	54·2	33½	262·79	4·69	·1403	26	133	290	4745	1160	53·9	126	6	
64	37	21·0	84·6	35	274·03	4·89	·0898	32	132	270	4418	1080	50·2	127	10	
38	47	16·9	68·4	36	282·14	5·04	·1215	28	119	360	5891	1440	67·0	113	8	
48		16·8	67·7		Ag. 1709·51	5·09	·1229	Ag. 173	126						9	

ces. Total average load, 205 tons. Circumference driving wheels 16·

Capacity of each cylinder, 4,824 cu. in. = 2,792 cu. ft. Maximum curve on section of roa

Area each piston, 201 sq. in. Apparent gross evaporation of wa

23	24	25	26	27	28	29	30	31	32	33	34	35	36
Record of Speed.								Locomotive Power.					Duty.
		Cut-off.											
Miles per hour.	Steam pressure at time of observing speed.	Adm'n—in. of stroke.	Decimal of stroke.	Mean speed per trip. Revolutions per minute.	Mean speed. Feet per minute.	Mean piston speed. Feet per minute.	Mean speed. Miles per hour.	Average tractive power.	Av. foot pounds exerted per minute, calculated from steam pressure and speed.	Equivalent indicated horse power developed.	Pounds of water consumed per horse power per hour.	Pounds of coal consumed per horse power per hour.	Apparent duty per 100 lbs. of coal, calculated from indicated horse power.
	LBS.							LBS.					FT. POUNDS.
44·6	114	10	·416	120	1962	480	22·3	7,520	14,664,960	444	15·9	2·4	81,021,900
44·6	104	10	·416	127	2077	508	23·6	6,827	14,090,904	427	20·1	2·5	78,282,800
48·4	128	8	·333	123	2015	492	22·9	6,827	12,647,096	383	18·7	2·0	96,542,700
53·9	126	6	·250	130	2121	520	24·1	5,739	12,124,320	367	19·2	2·2	90,480,000
50·2	127	10	·416	124	2033	496	23·1	7,817	15,751,968	477	14·8	2·6	75,009,400
57·0	113	8	·333	129	2112	516	24·0	6,135	12,860,784	390	24·0	2·6	76,099,300
		9	·375	126	2053	502	23·3	6,811		415	18·8	2·4	82,906,000

ving wheels 16·36 feet,

n section of road run over, 1200 feet radius.

vaporation of water = 1709·51 × 62·4 (col. 15) ÷ 14,520 (col. 9) = 7·35 lbs. per lb. of coal.

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Column
Column

Column 10 = col. 9 ÷ 56, miles per trip.

Column 11 = 56 ÷ tons in col. 9.

Column 12 = col. 9 ÷ col. 5.

Column 13 = col. 12 ÷ 14·84, area grate, and × 60, minutes in an hour.

Column 16 = col. 15 ÷ 56 miles.

Column 17 = col. 15 ÷ col. 9.

Column 21 = col. 20 × 16·36, circumference driving wheels.

Column 22 = col. 20 × 4 ft. for piston speed, = stroke × 2 × number of revolutions.

Column 30 = 56 miles ÷ col. 5. This speed is inclusive of stops.

Column 28, since 1 mile of 5280 ft. ÷ 60 = 88 ft. per minute, it = col. 30 × 88.

Column 27 = col. 28 ÷ 16·36 ft.

Column 29 = col. 27 × 4 as in col. 22.

Column 32. To obtain this, the number of foot-pounds exerted per minute has been calculated from the average *pressure*, *area of piston*, *point of cut-off*, *length of stroke*, and *mean piston speed*, using cols. 19, 26 and 29 as data. The effective pressure during admission was first obtained by employing this formula, stated in *Engineering*, $p' = \frac{4}{5} p = \cdot 8\, p$. The absolute pressure during admission was then found by adding 14·7 lbs., and the terminal pressure, at the end of expansion, with the given cut-off, by dividing this by the ratio that the length of stroke bears to that of admission. Multiplying this by the hyperbolic log. + 1 of the latter, as previously illustrated, the mean absolute and effective pressures were obtained. The latter, multiplied by the area of the two pistons, and the datum in col. 29, gave the result in col. 32, and dividing this by 33,000, gave the *indicated* horse power in col. 33, or the total unbalanced power exerted to overcome the combined resistances of friction and that due to the load or weight of train.

To calculate the mean tractive power, in col. 31, I first obtained the tractive power *per lb. of effective pressure per sq. in. on the pistons* by means of the formula $t = \frac{d^2 \times S}{D} = \frac{16^2 \times 24 \text{ in.}}{62{\cdot}5} = 98{\cdot}944$ lbs. (*S*, being the length of stroke; *d*, the diameter of the piston; and *D*, that of the driving wheels in inches), and multiplied this result by the mean effective pressures previously obtained.

Column 34 = col. 15 ÷ col. 5 (cubic ft. per minute) × 62·4 (lbs. per minute) ÷ col. 33 (lbs. per H. P. per minute) × 60 (lbs. per H. P. per hour).

Column 35 = col. 12 ÷ col. 33 (lbs. per H. P. per minute) × 60 (lbs. per H. P. per hour).

Column 36 = col. 32 ÷ col. 12 × 100.

Train Resistance.—If we put the tractive power of 5671 lbs. that we have obtained = R, we have the condition of uniform motion. The tractive power must balance the resistances. If the total resistance, R, is more than T, the engine will not move, or, if already in motion, its motion will be retarded; if less, the motion will be accelerated. I will not enter here into the discussion of the subject of train resistance. The total resistance to traction is made up of internal resistance due to the friction of the axles, and external resistances. The former forms a constant factor in the total train resistance; the latter constitute a variable one which increases, as far as the laws governing them have been determined, as the square of the speed. The external resistances are: the rolling friction of the wheels on the rails, the resistance of cars on a straight and level track, the additional resistance, caused by gravity, on ascending grades, the resistance due to the friction of the engine, the resistance of curves, the resistance of the atmosphere, the wind, and that caused by the lateral play of the wheels and transverse oscillations of the engine and train. The conditions affecting these are: the condition of the engine, and of the permanent way, the straightness of the track, curves, grades, the weather and wind.

Perhaps there is no subject upon which engineering authorities differ more widely than upon the resistance of trains at different speeds. In fact, they have never been more than approximately determined, and the English formulæ which we have, do not represent the conditions upon American roads. The best formula for a straight and level track is based upon one of D. K. Clark's, however. The fact that he ascertained was that the resistance to a train at 60 miles per hour was 21 lbs. per ton of train. Hence for any other velocity we should have $R : R' = v^2 : v_1^2$, whence $R = \frac{R'}{v_1^2} v^2 = \frac{21}{v_1^2} v^2 = \frac{v^2}{171}$. The constant resistance for American cars Mr. Forney takes at 6 lbs. per ton, so that the resistance of this train would be represented by

$R = 6 + \frac{v^2}{171} = 6 + \frac{(30)^2}{171} = 6 + 5{\cdot}2 = 11{\cdot}2$ lbs. per ton, or, in all, $11{\cdot}2 \times 205$ tons $= 2296$ lbs.

In order to find the resistance of the engine and tender alone, the method given by Weissenborn's "Engineering" is to find the resistance of the locomotive as a carriage by means of the formula $R' = 6 + \frac{v^2}{240}$, which gives 9·7 lbs. per ton, or 494·7 lbs. total; and add to it what he calls the "machinery friction," which is estimated to follow the formula $F = \left(2 + \frac{v^2}{600}\right) \times \frac{W + w}{W}$, in which W is the weight of the engine and tender, and w, the gross weight of the train. This gives for the machinery friction,

$F = \left(2 + \frac{(30)^2}{600}\right) \times \frac{205}{51} = 3{\cdot}5 \times 4 = 14$ lbs. per ton, or, in all, $51 \times 14 = 714$ lbs. The resistance of the engine alone would therefore be $494{\cdot}7 + 714 = 1208{\cdot}7$ lbs. to be constantly overcome at 30 miles per hour.

(To be continued.)

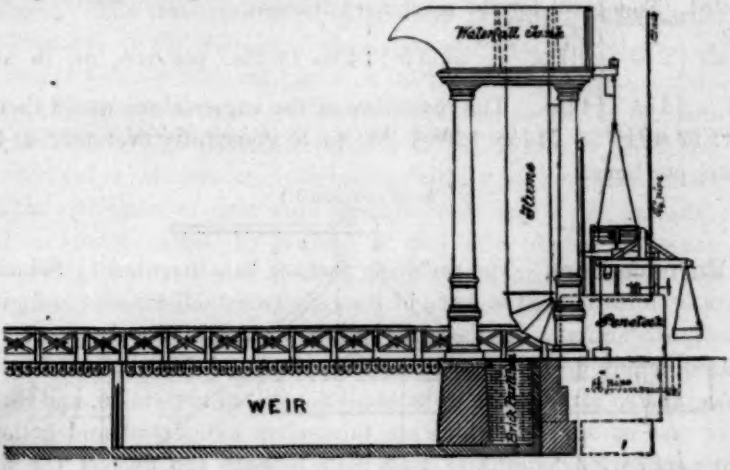
Furnace Bars.—The revolving furnace bars invented by Schmitz have been introduced in some of the London establishments, and give great satisfaction. In these the ordinary straight fine bars are replaced, singly or in pairs, by hollow cylindrical bars, pierced with holes, and so arranged as to be easily capable of revolution, and these bars rest on supports which are themselves cylindrical and hollow, being supported lengthwise by a plate beneath the door of the fire box, and fitting into a neck made at the near end of the bar. For revolving them a winch is inserted in the hexagonal opening in the front end of the bars, by which they are turned, in operation.

The lighting of the furnace, in this case, is performed in the ordinary way, and the furnace door can be kept completely closed; the perforations of the hollow bars supplying as much air as is necessary and to a much greater advantage, as it passes directly through the coal instead of playing on the top, and the combustion is much more uniform and thorough. At intervals the bar is turned partly around, and a clear surface free from slag is presented to the fuel. The ashes which fall through the perforations of the grate in this arrangement can be conveniently pushed out into the ash pit, thus avoiding the necessity of raking down.

TESTS OF TURBINE WATER-WHEELS AT THE CENTENNIAL EXHIBITION.[1]

The following extracts are taken from the report of Mr. Samuel Webber, Superintending Engineer of the Centennial turbine tests, to Mr. John S. Albert, Chief of the Bureau of Machinery.

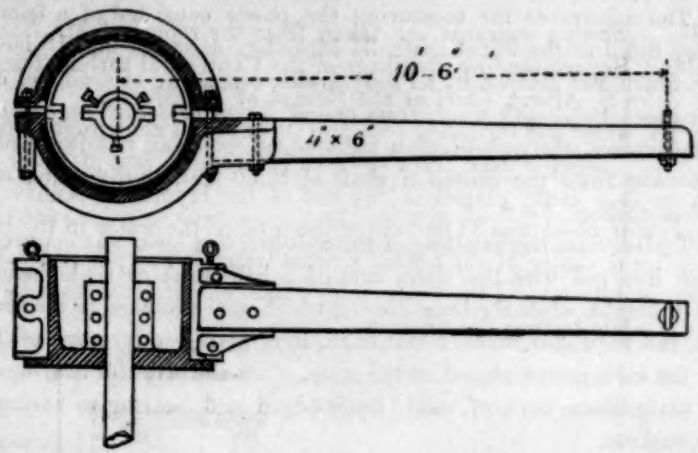
"The water was furnished by a pair of powerful centrifugal pumps, * * * which raised from 1800 to 1900 cubic feet of water per minute to a tank, placed at the end of the Hydraulic Annex, the overflow of which was 33 feet above the level of the water in the large tank in the centre of the building, from which it was pumped. This water usually formed the 'cataract,' which was stopped partially or wholly while testing the turbines.



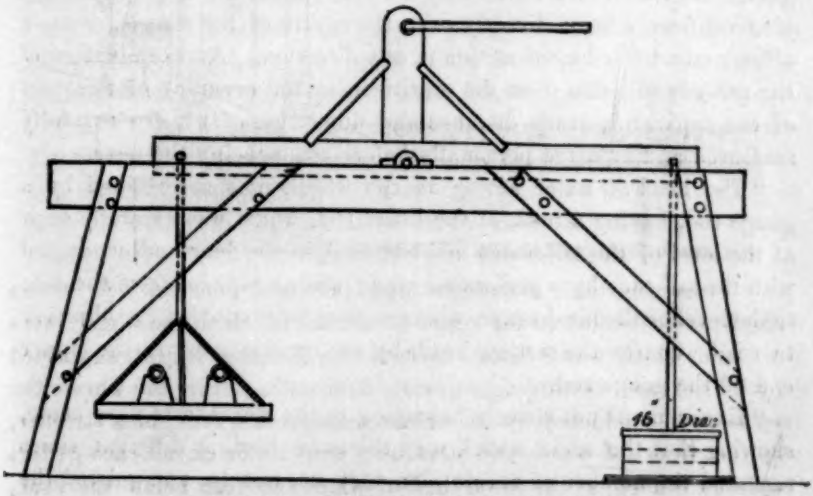
"From this tank a wrought iron tube or "penstock" 4 feet in diameter descended to the "flume," or case in which the wheels were set, and which was 8 feet in diameter by 6 feet in height, supported by a brick wall resting on a granite bedstone. From the wheels the water was conducted by an ample passage to a rack, or a strainer, 30 feet from the wheel, and stretching across a brick tail-race 14 feet wide by 8 deep, at the lower end of which, 15 feet below the rack, was the measuring weir, 9 feet long, formed of a heavy cast iron plate planed to a true edge $\frac{1}{8}$ of an inch thick, and beveled from that on the further side at an angle of 45°. The upright ends of the weir

[1] From advance proof sheets of the report of the Director General.

were made of Georgia pine, cut and beveled to the same dimensions, and were carefully adjusted.



Wheel 37.44″ diam., 18″ face, 1000 lbs. weight. Brake 1600 lbs. weight, leverage 132 : 1.



BRAKE FOR TESTING TURBINE WHEELS.

"The hook gauge * * * was placed in a tight wooden box 6 feet up-stream from the weir, and the water was admitted to this box, for the purpose of measurement of height, by a few ⅜ inch holes bored in the bottom of the box, 3 feet below the surface of the water; and an examination of the very thorough test of the Tait wheel shows

the sensitiveness with which the weir measurement responded to the changes of load and variation in the number of revolutions of the wheel.

"The apparatus for measuring the power consisted of a friction pulley fitted to the wheel shaft, 37·44 inches diameter and 18 inches face, which was clasped by a Prony-brake, consisting of a pair of cast iron shoes lined with wood, from one of which projected an oak arm 6 by 4 inches, through which a knife-edged eye-bolt was fastened at a distance from the centre of shaft of 10·50 feet, or the radius of a 66 feet circle. * * *

"To facilitate the handling of the weights, this lever was connected by an iron rod with the short arm of a bell-crank or scale beam 2 feet in height, while the longer arms, which were attached to the scale, pan, and regulator, were 4 feet each, thus giving a leverage of 132 to 1 for each pound placed in the scale. All the pivots or bearings of this scale-beam were of steel, knife-edged and bearing in hardened iron sockets.

"The pulley, weighing 1000 pounds, rested on the shaft and step of the wheel, corresponding in some measure to the usual "crown gear," but the brake, which weighed 1600 pounds, was suspended by a swivel from a beam directly over the centre of the wheels, so as to allow perfect freedom of motion in any direction. An examination of the records will also show the sensitiveness and accuracy of this part of the apparatus, every distance and dimension of which I carefully measured and adjusted personally before commencing the tests.

"The head of water acting on the wheels was ascertained by a gauge-rod, having a hook at the lower end, which was carefully kept at the level of the tail-water in a box sunk in the floor and connected with the tail-race by a perforated pipe; while a pipe led from the case to the level of the head water, where a glass tube enabled the observer to read at once the acting head, by the graduations on the upper end of the gauge rod.

"Experiments not strictly belonging to the wheel tests were made, showing that the same wheel, with the same load, at different times repeated the number of revolutions very accurately, and proved the correctness of the apparatus. The revolutions of the wheel were ascertained by a worm-gear clock, which was thrown in and out of connection with the shaft of the wheel, at signals given by a bell, which was struck at intervals of 1 or 2 minutes, according to the length of test desired.

"The friction pulley was accurately balanced before commencing the tests, and, when the wheels themselves were truly set, ran with perfect steadiness and regularity.

"Each exhibitor was allowed free access and liberty of observations during the tests of his own wheel; and, whatever may be the accuracy of the net results obtained, the comparative ones may be depended on, as the tests were all made under similar circumstances, and the different points watched and the notes taken throughout by the same observers, none of them having any interest whatever in the result, or any opportunity at the time of knowing what the observations were at other stations than their own.

"It is worthy of notice that the best results have been attained by wheels taken just as they came from the shop, without any especial finish or preparation, and the thoroughly exhaustive test of the Tait wheel is worth studying, as showing the accurate working of the apparatus.

"The Geyelin wheel, entered by R. D. Wood & Co., was so tightly fitted in the shop that I do not think we got a fair record of its power; and the Cope wheel used so much water that we could not carry the test out in full, but the percentage was gaining regularly up to the last trial, when we exhausted the supply of water, having reached over 1860 cubic feet, or about 14,000 gallons, per minute.

"The Hunt wheel also taxed the supply of water to the utmost. The Tyler wheel was too loose in the upper bearing on the second trial, and the third wheel, from the York Co., was only tested to prove or disprove what was believed to be an unsound principle, viz., that of shallow buckets and central discharge; and the result is confirmed by those obtained from some of the other wheels.

"The leakage of the flume was large during the first 6 trials, but by caulking and tamping with lead was very much reduced at the test of the Tyler wheel, after which test the allowance was uniform of 14,352 cubic feet per minute waste to each wheel. In the first 6 tests it was taken as noted in the tables, and the amount is in all cases deducted from the water consumed per minute."

Accompanying the report are full tables of the data obtained and the results as calculated therefrom. As it is impracticable to reproduce these tables entire, the one given herewith is constructed from them, and gives the percentage of useful effect of the various wheels. The head of water under which the tests were made, varied but a few inches either way from 31 feet.

TEST OF TURBINE WATER-WHEELS AT THE CENTENNIAL EXHIBITION.

	NAME AND ADDRESS.	Diameter of Wheel.	Percentage of Effect.								
			Full Gate.			¾ Gate.			½ Gate.		
			Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
	Barber & Harris, Meaford, Canada, . .	20 in.	76·08	67·85	73·43	71·30	66·09	68·69	71·77	48·70	60·28
i	T. H. Risdon & Co., Mount Holly, N. J., .	30 "	87·68	85·44	86·55	82·41	81·12	81·76	75·35	73·16	74·54
	Knowlton & Dolan, Logansport, Ind., .	24 "	77·43	76·22	76·67	.....	.....	.....	62·73	61·94	62·23
ii	A. N. Wolf, Allentown, Pa., ...	24 "	74·80	70·91	72·97	74·00	69·10	71·39	64·90	61·48	63·22
iii	John T. Noyes & Sons, Buffalo, N. Y., .	24 "	65·66	61·23	62·79	61·27	58·40	59·97	52·52	50·05	51·34
	Goldie & McCullough, Galt, Canada, . .	27 "	82·20	73·30	78·27	71·93	70·00	70·96	60·50	56·70	58 10
iv	Putnam Machine Co., Fitchburg, Mass., .	30 "	79·55	75·27	77·31	79·85	70·24	73·66	67·10	66 00	66·55
	Wm. F. Masser, Allentown, Pa., . . .	24 "	75·09	72·68	74·12	.....	.....	.....	65·80	63·80	65·11
v	York Manufacturing Co., York, Pa., . .	27 "	73·60	63·60	69·60	67·45	66·56	67·00	67·50	65·90	66·70
	National Water-Wheel Co., Bristol, Conn., .	25 "	83·70	75·80	80·70	70·50	67·30	68·90	.....	.....	.....
	E. T. Cope & Sons, West Chester, Pa., .	30 "	78·70	66·70	70·00	.....	.....	.....	.....	.....	.....
vi	Thomas Tait, Rochester, N. Y., . . .	25 "	82·03	73·60	79·28	72·60	69·60	70·80	66·20	65·00	65.43
vii	R. D. Wood & Co., Philadelphia, { Geyelin Duplex, . .	36 "	77·40	75·60	76·74	.....	.....	.....	.....	.....	.....
	{ " Single, . .	36 "	83·30	76·80	79·41	.....	.....	.....	.....	.....	.....
	Chase Manufacturing Co., Orange, Mass., .	24 "	68·30	60·20	62·99	67·60	62·10	65·74	57.30	55·70	56·60
viii	Rodney Hunt, Orange, Mass., . . .	24 "	78·70	76·60	77·95	71·40	71·00	71·22	68·72	68·38	68·56
	Stout, Mills & Temple, Dayton, Ohio, . .	30 "	68·40	66·60	67·50	.....	.....	.....	69·13	62·80	66·55

NOTES TO TABLE.

[i] A note accompanying the record says: "A full gate test at 280 revolutions per minute showed a better apparent result than either of the above, but is omitted from a little uncertainty as to the weir reading. The power attained was 85·42 P."

[ii] Two tests were made of this wheel and the mean result is given. There is a difference of 1·88 per cent. in favor of the second test with full gate, and of 3·36 per cent. in favor of first test at half gate.

[iii] The test at full gate was extended into the second day with better results than on the first day. The mean of both is given.

[iv] Two tests were made, of which the first and best is given. In the second test the "upper bearing of shaft loosened."

[v] There were three wheels from this firm tested, the second of which is given, it also being illustrated in the report. The first one was 26¼″ diam., and at full gate gave the same percentage of effect within a small fraction, but at three-quarters and half gate gave 62·90 and 59·95 per cent. respectively. The third wheel was 27″ diam., centre vent, and gave low results.

[vi] This wheel was tested with as little as one-eighth gate, and developed 16·85 H. P. and 35·20 per cent. of effect.

[vii] Three tests were made with the Duplex wheel, the first and best being given. Notes accompanying the record indicate that the wheel bound in the case and step. The single wheel also bound in the step.

[viii] Note says: "Very difficult to supply water at full gate. Head ran down several times and tests were rejected." K.

Hot Air Signal Pipes.—M. Montenat has experimented with copper tubes, containing red-hot network or little furnaces of glowing coals, by which he produces sounds of a great intensity, the musical note being modified by the position of the heat in the tube and by the length of the tube itself. He would like to construct, for the Exposition of 1878, a large apparatus on this principle, to produce sounds which can be heard at great distances. He believes that fog signals of such a character would have many advantages over those which have hitherto been used.—*Société d'Encouragement pour l'Industrie Nationale*, Jan. 12, 1877; *Les Mondes*, Feb. 15, 1877.

C.

Street Tramways.—At the meeting of the Society of Arts, London, held February 7th, 1877, Capt. Douglas Galton, C.B., F.R.S., etc., read a paper[1] on street tramways, in which he gave much valuable information relative to the comparative cost of horse and of mechanical traction on such roads.

The paper discusses motive power by steel springs, ammonia, superheated water and compressed air, but gives no estimate of cost of these, except in the Scott-Moncrieff compressed air street car, which the inventor claims to be able to run for 2·997*d.* per car mile.

Of the steam street cars in use in England, those given as the most successful are the Merriweather, which is a separate locomotive drawing the usual cars, and the Granthan steam car, carrying its own motive power; preference seems to be given to the latter. Both of these have been made to comply with the somewhat stringent regulations of the Board of Trade.

The cost of traction per car holding 44 persons, drawn by two horses, on the Bois de la Chambre tram road at Brussels, having gradients of 1 in 33, and an incline nearly 1¼ miles long of 1 in 100, is given as follows:

Cost of Stabling, 10 horses,	per day,	£0 02	0.
" Food,	" 2*s.* 1*d.* "	1 00	10.
" Harness, etc.,	" 10*d.* "	08	4.
Sinking fund for Horses @ 20 per cent. on £375, per day, . . .		4	1½.
Total cost per car per day,		£1 15	3½.

The horses travel a total of nearly 16 miles each.

The cost of steam traction on the same road including 5 per cent. interest on engine, and 10 per cent. for repairs and sinking fund, is 18*s.* 3*d.* per day.

On the Wantage tramway, which is 2½ miles long and has a gradient of 1 in 50 for 350 yards, and several sharp curves, the cost of working the Granthan steam cars is 17*s.* 6*d.* per day, or 5½*d.* per mile, against 27*s.* 6*d.* per day, or 8½*d.* per mile when worked by horses.

In the discussion which followed the reading of the paper, it was claimed that in Paris where 30 of the Merriweather steam tram cars are running, that they are run at a cost of 48 francs per day of 16 hours, and that they can be run in England at a cost of 3*d.* per mile against 7*d.*, the cheapest rate by horse power. K.

[1] *Journal of Society of Arts*, February 9th, 1877.

STREET PAVEMENTS.

[Contribution from the Department of Civil Engineering, Towne Scientific School, University of Penna.]

By Prof. LEWIS M. HAUPT.

Since the days of MacNeill, Telford, McAdam, Parnell and others, volumes have been written upon this subject, yet we have in many localities pavements which are a disgrace to a community making any pretentions to scientific knowledge.

This results either from a misunderstanding of all the conditions of the problem or an inability to fulfil them. The conditions, it is true, are intricate and variable, depending on location, grades, nature of merchandise, vehicles, power, subsoil, finances, etc., but in this monograph we propose to discuss briefly only the requirements of the *surface covering*, and to determine in the light of a long and varied experience what material will best fulfil all the conditions of a crowded thoroughfare.

The requirements of the surface are that it shall be: (1) firm and elastic; (2) noiseless, clean and dry; (3) smooth, yet rough; (4) permanent, yet easily removable; (5) light, yet heavy; (6) it should be durable, producing a minimum amount of wear and tear; (7) it must also be cheap and readily obtainable, and (8) non-combustible.

The impossibility of selecting any one of the available materials, wood, stone, brick, cement, iron, or asphalt, which will fulfil all the above conditions, is apparent. A compromise must therefore be made, and one or more selected which will approximate most nearly to the requirements of the case.

It is interesting to observe the ingenuity displayed by advocates of a particular material, in making it conform to every want, and in *theory* all of the above materials have been found to answer equally well, but from a practical, rational and disinterested point of view it is impossible that such should be the case; *e. g.*:—

Vegetable Substances, containing within themselves nitrogenous principles, elements of decay and putrefaction, should be rejected from sanitary considerations alone, but in addition to this their combustibility, softness of fibre, permeability and cost, are serious obstacles, and the experience of numerous trials on both continents, under varied

conditions, has proved them failures as to durability. We feel entirely justified, therefore, in omitting this material from the list of available substances until some more efficient means be successfully introduced of preserving the blocks, draining the foundation and preventing dry rot.

Iron has been used in various forms, but being a manufactured article, it is more expensive than stone or wood which are natural products. Hexagonal and other forms of blocks, covered with studs, and standing on legs which were driven into the foundation, have been discarded because of the noise, expense and insufficient foothold. Wherever tried in the form of blocks, iron has been found very objectionable, and its use is now restricted to tram and railroads.

Bitumen is a natural mineral product, belonging to the class of hydrocarbons, and may be found either solid, as in *asphaltum*, or liquid, as in mineral tar. It is used chiefly as a matrix for harder materials.

The best asphaltum is imported from Seyssel, in France, and Neufchâtel, Switzerland, but a tolerably good article is also obtained from the island of Trinidad. This substance melts at a comparatively low temperature, and is quite brittle when cold, so that it possesses properties which render it inappropriate for roads when subjected to great ranges of temperature and heavy traffic. When used, however, with sand and cement it forms an excellent suface, so far as smoothness and durability are concerned.

The wooden pavement on Pennsylvania Avenue, Washington, has recently been replaced by another, part of which is composed of Neufchâtel bituminous limestone, one and three-quarters inches thick, laid on a foundation of eight inches of cement, and the remainder of "Grahamite" (pure asphalt from Ritchie County, Va.), two and a half inches thick, on a similar foundation.[1]

Brick, being merely clay indurated by burning, is too brittle for ordinary travel. We find ourselves, therefore, restricted to the use of stone or cement as fulfilling most nearly the requirements of a good road covering.

But *Stone* occurs in a variety of forms, as in "cobbles," boulders, "spalls," or blocks, and in sizes which vary as the ratios of their three dimensions. Of the three first mentioned forms it is difficult to decide

[1] Letter of Gen'l Q. A. Gillmore, and his work on Roads and Street Pavements, page 182.

which is most injurious, yet these are the favorites with the community, because of their cheapness (?), and with the contractors, because of the proportionately large margin of profit, and necessity of frequent repairs. By this general and brief analysis we are induced to believe that stone of a regular geometrical form is that which is most suitable for the purpose; cement being an artificial monolith, whose dimensions may be extended at pleasure, is included in this class. It is not intended to review in detail the whole question of the adaptability of the various materials to the object in view, as this has already been done in an exhaustive and able report of forty-one pages, made by eight eminent engineers,[1] and published in the JOURNAL of September, 1843, but to review and emphasize the conclusions therein deduced. It was recommended to use a pavement of "dressed stone," laid diagonally upon a foundation of concrete, in those squares where the sewers and various supply pipes were completed, and to lay stone tramways on the steep gradients from Front Street down to Delaware Avenue. These are substantially the conclusions we are forced to adopt, even after the lapse of these thirty-four years, yet in all this time they seem to have gained but little ground.

A tramway in connection with a "Belgian" block system would fulfil all the requirements in the best and most economical manner. Trams, eight inches deep, and two feet wide, if well laid, would oppose the least possible resistance to the wheels of vehicles, and would be noiseless, whilst the blocks between would furnish the desired foothold, and the clicking of the horse's feet give sufficient warning of the approaching vehicle.[ii] This arrangement supposes the conditions of the horse and carriage to remain constant, and until lately it has been assumed that these elements of the problem were fixed, but rubber tires have been introduced and give great satisfaction. Still the roughness of the pavement required to furnish the necessary foothold has been found

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[1] The members of this committee appointed by the Franklin Institute June 26th, 1843, to report to City Councils on "The best modes of paving highways," were:

Elwood Morris.	George W. Smith, deceased.
Jno. C. Trautwine.	Jos. Saxton.
Henry R. Campbell.	M. T. W. Chandler, deceased.
Solomon W. Roberts.	Sam'l V. Merrick, deceased.

[ii] Tram stones of the above dimensions can be furnished and laid, of Old Dominion granite, at a cost of $3.25 per lineal yard, whilst Belgian blocks, covering the same surface, are worth $2.25, making the trams cost one dollar more per yard, but every other consideration is in their favor, and ultimately they are cheaper.

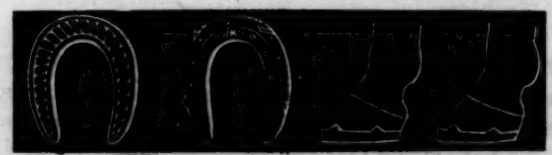
to cut and destroy them so rapidly as to render their general introduction improbable. If now we can substitute for the present shoe a material that will prove as durable and as secure, at the same cost, it will open the way to great reforms in all the elements of locomotion, viz. :—the pavement, the vehicle and the power.

Such an improvement has indeed been made and tested satisfactorily. It consists of a hollow shoe of the ordinary shape, open at the bottom, and having iron studs projecting vertically downwards through a three-quarter inch tarred rope which they hold in place, and which serves as a packing. The shoe is put on without heating and held in place by six nails. It has been used until worn down to a knife edge, and its life is quite as long as that of the ordinary iron shoe. The rope is not kicked out by use, but is in fact riveted firmer by the pounding down of the studs.[1]

The general introduction of such an improvement would undoubtedly lead to the substitution of concrete for the rumbling rubble pavements now in use. The chief objection, lack of sufficient foothold, having been overcome, minor difficulties need have but little weight, as that portion of the surface overlying sewers, etc., might be divided into blocks which could be readily removed and replaced. The necessity of breaking the surface for pipes could easily be avoided by laying them hereafter under the sidewalks or in rear of the dwellings, in streets of the second class.

There *is* a street in Philadelphia (a short one to be sure), upon which there is no railway, and whenever a wagon or cart passes at a trot it shakes all of the buildings, which are said to be substantial. What must be the waste of energy that will set in vibration the houses on both

[1] The sketch below indicates the outline of this shoe. It is cast of malleable iron, of the usual shape of a horse-shoe, having its lower face open, into which a slip of tarred rope is pressed of larger diameter than the width of the opening; a range of prongs rises in the centre of the cavity which pierce the rope, and thus uniting with the stress from the sides, hold the hemp firmly. The shoe partakes somewhat of the moccasin and also of the sandal; it absorbs concussion and retains friction, and embraces conditions of fitness such as I never saw associated before.—H. O.



Under surface. Upper surface. Shoes in position.

sides of a street whenever a vehicle passes? Yet the injury is not limited to the vehicle, the edifice, nor the road covering, all of which are badly shaken up, but extends in a greater degree to the animal life affected by it: the horse, and the individuals in the house or conveyance. It is a constant strain upon the nervous system of women, invalids and children whose sleep is disturbed and restless. The racket is especially noticeable by visitors from rural districts, who are unaccustomed to such a continual jarring. This enormous waste of energy can and should be avoided by recourse to proper engineering expedients, and no one will deny that a uniformly smooth, even and continuous surface, such as that furnished by a good cement pavement, with only joints enough to permit of expansion, would fulfil in the most perfect manner all the requirements for the horse, carriage, passenger and resident, could be kept perfectly clean, and when once laid would require the minimun amount of expense for repairs and police.

Before closing there is another point which is worthy the consideration of the enterprising and progressive citizen, and that is the large amount of space wasted by front steps. In many streets at least half the footwalks are interrupted by such projections, forming useless dead spaces between them which serve to collect the snows of winter, to be piled up in the street, forming impassable obstructions for a considerable length of time. The steps themselves, exposed as they are, become dangerous from ice, and are not an architectural necessity nor ornament. Every consideration of humanity would suggest their being withdrawn, and, when necessary, occupying the place of the vestibule, leaving an open recess or niche in the place of the outer door. Thus the visitor or resident would be sheltered from sun, wind, rain or snow whilst waiting the answer to his summons; the steps would not be dangerous by being coated with sleet; the suggestion of hospitality would be extended by the apparently open door, which effect would be heightened by an outside lamp at night, and the full breadth of the sidewalk left available for a promenade, with rows of trees, if desired. The plan is not a new one, but is in use in many cities of this country and the continent.

Carbon for Electric Light.—M. Th. du Moncel forms a compressed mass of carbon and magnesia, which is very hard and burns without ash, giving a light which is steadier and 34 per cent. more intense than that of gas carbon.—*Ex.* C.

Chemistry, Physics, Technology, etc.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS, DURING THE LAST TEN YEARS.[1]

By Dr. A. W. Hofmann.

From the *Chemical News*.

[Continued from Vol. ciii, page 274.]

The Belgian pyrites kilns have generally fixed grates. Beneath them is a large channel connected with the chimney. Before introducing a fresh charge of ore the workmen go into the channel and remove the exhausted ore which lies upon the grates with long iron hooks. Not to be inconvenienced by dust during this operation they open the damper which connects the channel with the chimney, so that fresh air rushes to them in plenty. This arrangement affords at the same time a further advantage. If the access of air to the furnace could be hermetically closed it would be possible to hinder the escape of sulphurous acid when the doors are opened for the introduction of a fresh charge. But as hermetic closing is not practicable in kilns the loss may be avoided with the aid of the long channel. The outer door leading into the channel is closed as tightly as possible, and the damper leading to the chimney is opened just so wide that the air which enters the channel through the imperfect joints of the door passes beneath the grate bars into the chimney, and not up between the bars into the kilns. Too strong a draft would draw air down through the upper or working doors into the kilns, and consequently sulphurous acid would escape from the chimney. The combustion is therefore at a standstill till the new charge is spread out in the kilns; then the damper is closed, and the door leading into the channel is opened as far as the proper working of the kilns requires.

In France movable furnace-bars have been used in the pyrites kilns for some sime. They were, indeed, already known in 1848. They

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1 "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

are convenient for the workmen, and afford besides the advantage in roasting, that on moving the bars backwards and forwards, only the lowest stratum of the charge falls out. The compartments are mostly separated from each other by arches; the kilns resemble the English pattern, but the stratum of ore is shallower, as for the most part richer, more combustible pyrites are employed.

In Germany kilns for lump pyrites are in use, of the French, the Belgian, and the English kind. A combination of the French and the Belgian kiln was introduced in 1866 in the "Rhenania" chemical works, near Stolberg, and this construction has since been more extensively adopted. The burnt ores are removed by means of revolving bars, because, on the Belgian method workmen often penetrate with their long hooks into layers still rich in sulphur, and thus the burnt ores show too high a percentage. In the "Rhenania" the long Belgian channel beneath the grates has been retained, permitting the introduction of a fresh charge without loss of sulphurous acid. It further permits the introduction of a wagon beneath the kilns, into which the spent ore falls at once and can be removed without the trouble of loading.

If the slope of the ground permits no other arrangement, the wagons may have a low shape, and the tramway may be on the same level as the floor of the furnace. At the Rhenania and in other places where the pyrites can be brought up on to the kilns without difficulty, the charge of lump-ore is introduced through an aperture in the vault, and the process does not take more than 20 secs. If it is too difficult to convey the ore upon the top of the kilns, it is thrown in with shovels through the working door. In this manner 400 kilos. can be introduced in five minutes. As charging always disturbs the progress of the furnace, it is advisable to restrict it to a minimum of time.

Poor lump-ores are roasted in Freiberg and Oker in small shaft furnaces with a lateral exit for the gases, and a low vault in which a high layer of ore is constantly maintained.[1]

As for the roasting of smalls and rough fragments, it is sometimes carried on along with the lump-ores. This method is not advantageous, and renders the burning of the whole of the pyrites imperfect.

It is better to work up the smalls into balls (Klütten, Stöckeln, *Boulets*).

[1] Compare Graham-Otto's *Lehrbuch*, Band 2, abth. 1, 549.

For this purpose they are mixed with more or less clay and water, and moulded into balls or cut in pieces. The dried balls are then burnt either alone, or mixed with lump-ores in the kilns described above. English establishments which burn Spanish cupriferous pyrites mix the finely ground ore with water, without clay, and mould the paste into balls, which hold together owing to the presence of vitriol.

For roasting smalls and coarse powder several kilns have been latterly proposed.

In 1862 the so-called shooting-kilns were introduced at Freiberg, their original and ingenious construction being due to Moritz Gerstenhöfer. They have been described in most technological journals, and in Schwarzenberg's "Treatise on the Manufacture of Sulphuric Acid" (p. 415), they are represented in figures drawn to scale. F. Bode, assistant in Gerstenhöfer's technical office, describes them in detail in his pamphlet "Contributions to the Theory and Practice of the Manufacture of Sulphuric Acid."[1] He deals at length with all the objections to Gerstenhöfer's furnaces, and endeavors to refute them.

The ores to be burnt in Gerstenhöfer's kilns must first be ground to a fine powder. They are desulphurized whilst falling from a shaft of about 5 metres high, 1·25 metres wide, and 0·8 metre deep. This shaft is fitted up with three-sided prisms of fire-clay, arranged with one angle downwards and one side upwards so that intervals remain between them, and the particles of ore fall from one prism to the next. The raw ore is introduced continuously by means of a hopper, and the burnt residue is withdrawn from time to time below. The furnace is heated with wood and coal previously to entering the ores, and as soon as they are introduced the fire is withdrawn, as the cumbustion of the sulphur keeps up the necessary temperature. Rich ores are passed through the kilns in small quantities and poor ores more rapidly.

Instead of putting in furnace bars below and removing them again when the kiln is warm, the author introduced a permanent lateral fire in the Gerstenhöfer kilns built at Stolberg, which was ready for use on a change of ores or any interruption of the process. In Stolberg the burnt ore, also, was drawn at once out of the furnace into a truck, introduced below the bottom sliding plate. Both these arrangements were considered by Bode as improvements.

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[1] "Beiträge zur Theorie und Praxis der Schwefel Säure Fabrikation."

Gerstenhöfer's kilns afford the great advantage that poor ores may be burnt without the aid of fuel, so as to produce rich gases of a constant composition and fit for the chambers. If perfect burning is not required they are unequaled. At Vedrin, in Belgium, where the good pyrites are sold and only the inferior qualities are used for the preparation of acid, satisfactory results are obtained with them, as in Freiberg, where a mere preliminary roasting of mixed ores is required.

For roasting rich smalls this furnace has not come into general use, and is employed neither in France nor in England (except for copper ore at Swansea). It has been abandoned at the chemical works at Chauny (Dep. Aisne), of Widnes (Lancashire), of Nienburg on the Weser, and of Stolberg, on account of imperfect burning and excessive production of flue-dust.

A furnace for smalls invented by Perret was shown as a model at the Paris Exhibition of 1867, and has been fully described by Schwarzenberg.[1] This furnace consists of several stages of horizontal plates arranged above a kiln for lump pyrites. These plates are fixed at intervals of 30 centimetres, and are covered with smalls to the depth of 5 to 8 centimetres. The hot gases from the kilns below sweep over them whilst ascending, and exhaust them of sulphur. Perret's furnace has been in action for years in the Wohlgelegen Chemical Works, near Mannheim, but otherwise it has remained confined to France. As originally designed, it rose to the height of 6 metres above the furnace, and required much labor, as the ores had to be pushed up from stage to stage, whereby also some sulphurous acid escaped. The most recent Perret furnaces are essentially modified and act very satisfactorily. They are a little above 2 metres in height, and have only four ranks of plates, which can all be charged from the level of the furnace. The ore burns clean on every plate, and does not require to be pushed up from below. In this manner equal weights of lump and smalls are burnt.

Maletras, of Rouen, set up a plate furnace on Perret's principle, in which rich smalls are thoroughly roasted alone without lumps, and without the aid of coal. Similar kilns are in use at Dieuze and near Berlin. The roasting of poor smalls at Dieuze has proved unsatisfactory, although the ore was dried before charging the furnace.

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[1] Bolley, "Handbuch der Chem. Technologie," ii, 421.

Smalls of 46 to 48 per cent. of sulphur were burnt down to 3 or 4 per cent.

In 1861 Peter Spence patented a furnace in England[1] similar to those which had been in use for twenty years in Belgium, and at Stolberg, near Aachen. The furnace was worked with fuel, which heated a muffle, constructed of arches, for the reception of the ores. Much air entered through the working doors, so that the gases contained but little sulphurous acid. A kiln of this kind is still in use at the works at Imeary, near Newcastle-on-Tyne. In Spence's establishment it has fallen into disuse, and has altogether found but a very limited application.

Allhusen, of Gateshead, burns smalls on iron plates above the lump pyrites. Nothing has transpired concerning the working of the process.

The "Rhenania" Chemical Works of Aachen exhibited at Vienna, in 1873, models of the kilns which were first constructed at Stolberg, on the principle of Wilhelm Helbig and the author.[ii] These kilns serve for burning finely powdered sulphur ores, and especially for iron-pyrites and zinc-blende. The peculiarity in the construction is that the ores are roasted upon strongly inclined planes, down which the pulverulent mass slides when a portion of ore is taken away from below.

The plate furnace described in 1870 is in extensive use for burning the smalls resulting from breaking up the ores, and is at present being set up in several manufactories. It is charged with a mixture of coarser and finer fragments, sand-ore, and meal-ore. The lumps are burnt in the ordinary manner close by the plate tower, and the hot gases escaping, sweep over the plates and burn the smalls. The ore passes over the plates in the form of a continuous stream, the thickness of which is determined by the interval between two plates. Green ore is added and burnt ore withdrawn without interrupting the process. The upper aperture is kept covered with a heap of ore, so that as it slides down no sulphurous acid can escape at the hopper. At the lower part of the furnace the burnt stratum of pyrites is removed by means of a roller, which revolves automatically every five minutes, and is driven by a small water-wheel. Paul Seybel, of

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[1] A. D., 1861. Specification No. 3002.

[ii] *Zeitschr. d. Ver. Deutsch. Ingen.*, 1870, p. 705, and 1872, p. 505.

Liesing, near Vienna, works the kiln intermittingly, withdrawing about 200 kilos. of burnt ore every six hours by turning the roller. As smalls in very fine powder do not slide down well, Seybel's method is preferable for such ores. At Liesing, ores from Bösing, in Hungary, are burnt in plate kilns down to about 4 per cent., and Styrian ores down to about 7 or 8 per cent. The burnt lumps of the latter kind retain 5 to 6 per cent of sulphur, whilst lump ores from Bösing burn down to 2 per cent.

Burnt smalls from the "Sicilia" mine, near Siegen, retain 4 to 5 per cent. of sulphur according to the size of the furnace and the quantity of ore passed through it. The burnt lumps which have been roasted along with smalls retain 5 per cent. of sulphur, whilst clean lumps burn down to 2 per cent. There is therefore a decided improvement in roasting these kinds separately.

The before mentioned plate-furnaces give in most cases very satisfactory results.

At Oker in the Harz, a plate-furnace was built for hammer dust, poor in copper but rich in sulphur, such as the Rammelsberg yields in quantity. The operations carried on were changed in the meantime, and when the structure was complete it was no longer found desirable to burn the ores in the plate-furnace for which it was intended. It was charged with ores rich in copper, the burning was not satisfactory, and the furnace was removed.

Hitherto only one plate-furnace has been built behind each kiln for lump pyrites, instead of arranging a system of plates above each compartment of the kiln, as in Perret's furnace.

For the utilization of the hammer dust from lump pyrites, a tower suffices, as given in detail in the plans published, capable of burning every twenty-four hours 600 to 1000 kilos. of ore, the granules being from 1 to 12 millimetres in diameter. Other combinations would permit a richer charge, and such will doubtless be built.

The construction described in the journal above cited (1872, p. 505) will be further considered when we treat of roasting blende. This furnace requires the maintenance of a separate fire to keep up the heat, and is only to be recommended where coal and smalls are cheap.

Experienced technologists have proposed furnaces with inclined plates, in which smalls may be burnt without the action of lump pyrites and without especial firing, as in the furnace of Maletras. Where rich pyrites are accessible, such arrangements may prove advantageous, but we have no experience as to their action.

Determination of Sulphur in Pyrites.—The determination of the sulphur in the burnt ores is generally effected as follows:—The finely powdered ore is heated in a flask with a mixture of 2 parts nitric acid and 1 part hydrochloric, evaporated to dryness, and again treated with hydrochloric acid to expel any nitric acid. The sulphates are then dissolved by treating the residue with hydrochloric acid and water, filtered, and the sulphuric acid in the filtrate is determined by means of chloride of barium. Chemists have made many attempts to place a more expeditious method in the hands of the manufacturer.

In 1861, Pelouze[i] published a process in which the ores are treated with chlorate of potassa and a weighed quantity of pure carbonate of soda in a platinum crucible. The melted mass is dissolved in water, and the excess of soda is determined volumetrically by saturation with a standard acid. Barreswill called attention to a source of error in this process in case of the presence of arsenical compounds in the ore. Bottomley and Bocheroff also pointed out its inaccuracy. J. Kolb[ii] made some interesting comparative experiments between the determination of sulphur by the above mentioned gravimetric process and the volumetric method of Pelouze. The results differed by several per cents. Kolb found that the source of error consisted, on the one hand, in the formation of silicate of soda, and, on the other, in the decomposition of chlorate of potassa in presence of oxide of iron into chlorine, oxygen, and caustic potassa. Kolb proposes to fuse the finely powdered ore along with 5 grms. soda and 50 grms. oxide of copper at a dull red heat; to treat the melted mass with hot water, to filter, and determine the excess of soda in the filtrate volumetrically.

In the Freiberg works[iii] 1 grm. of finely ground ore is mixed with 3 grms. anhydrous carbonate of soda and an equal weight of saltpetre. This mixture is placed in an iron crucible melted in a muffle at a red heat, the mass is dissolved in hot water, and the liquid is filtered into a beaker, in which there is a little hydrochloric acid to saturate the excess of soda. The liquid, which should have an acid reaction, is then boiled for a short time, and the sulphuric acid is determined volumetrically with a solution of chloride of barium, standardized, so that 1 c. c. indicates 2 per cent. of sulphur.

[To be continued.]

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[i] Pelouze, *Ann. Chim. Phys.*, 3, 63.

[ii] J. Kolb, "Notes sur l'essai des Pyrites," 1869.

[iii] Schwarzenberg, *opus citat.*, p. 424.

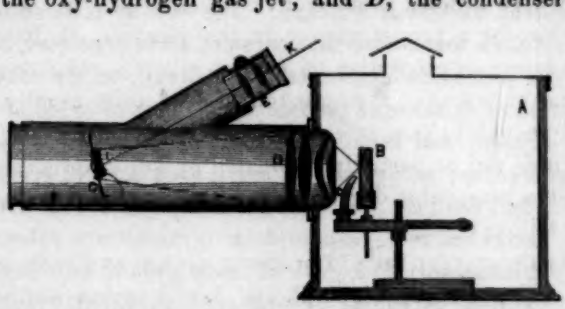
A NEW FORM OF MEGASCOPE.

By J. B. KNIGHT.

The projection on the screen of the images of small opaque objects is often a very desirable means of illustrating lectures or papers read before societies, but has not been very largely employed, because of some difficulties attending its use.

As the light for forming the image is only that emanating or reflected from the surface of the object, it is important that it be strongly illuminated. The arrangement about to be described, was devised to secure a better illumination than is obtained with the ordinary megascope, and at the same time save the cost of a special instrument, by utilizing the ordinary projecting lantern with which nearly all our educational institutions are provided.

The arrangement for accomplishing this purpose is shown in the accompanying cut, in which *A* represents the lantern box; *B*, the lime; *C*, the oxy-hydrogen gas jet; and *D*, the condenser;—all of



the ordinary constituents. *F* represents a tube of sheet metal, of the proper size, to fit snugly over the ring of the condenser, and of sufficient length to reach considerably beyond the focus of the beam of light from it. The object *I* is held, by the stage *G*, in the beam of light as near its focus as possible, and yet give the proper breadth of illumination. This stage *G* is supported by, and hinged across its centre to, the inner movable tube *R*. To the tube *F* is attached a branch for holding the focussing lens at the proper distance from the illuminated side of the object, with its axis at as small an angle from the axis of the condenser, as will permit the cone of light passing from it to the screen to clear the top or sides of the lantern box.

Objects are easily placed on the stage *G*, by withdrawing the inner tube *R*, and are easily adjusted by this longitudinal movement, and the angular movement of the stage on its hinges.

This attachment is simple and inexpensive, and by it the usefulness of the projecting lantern is greatly increased.

What shall be done with the old rails?—The rapid increase in the manufacture of Bessemer steel, and the great reduction in the cost of production, have enabled our railroad corporations to substitute steel for iron rails, on very favorable terms. In order to make the substitution, the railroad officials desire to sell their old rails, and in order to secure orders, the manufacturers are often induced to yield imprudently to that desire, by accepting too large an amount of old stock in exchange for the new. M. G. Bresson[1] supposes a proposition to be made in the following terms:

"I need 10,000 tons of steel rails for the maintenance of my track, and I will give you in exchange 10,000 tons of iron rails. What will you charge to work them over?"

In seeking for a proper answer to the question, M. Bresson considers the injurious properties of copper, silicium, sulphur and phosphorus, and shows that a single ton of iron rails usually contains impurities enough to ruin several tons of Bessemer metal. Some of the impurities can be partially eliminated by known processes, but he thinks that a reasonable degree of prudence would require a reply, nearly as follows:

"I will subject your rails to proper analyses, and such as contain less than 0·2 per cent. of phosphorus, I will accept at the market price of old iron rails, delivering new steel rails in return, also at the market price. As to those which contain a larger proportion of phosphorus, I will re-roll these as iron rails, or, if you wish nothing but steel, I will fill your order with Bessemer rails, made of good materials. But I cannot take your bad rails, except at the price of my worst metal, for I must run the risk of keeping them for years in my inventory, and perhaps even of never using them."

In the present depressed state of business, the temptation to make more favorable offers is so strong, that some manufacturers may be willing to overstep the bounds of prudence, under a hope to work off

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[1] *Annales des Mines*, vol. x, pt. 4.

the temporary surplus of iron stock at some favorable future opportunity. If the hope is not realized, there is reason to fear that excuses will be found for filling remote orders with a metal of inferior quality. C.

Relation between Meteorologic and Magnetic Disturbances.—In a communication to the Belgian Academy, Van der Mensbrugghe remarked: "If the least quantity of vapor which arises from a liquid, produces a diminution of temperature and electric disturbance, what powerful thermal and electric effects may we not expect from the immense variations of free surface in the waters which cover the earth, and in the vapors which rise into the air?" Secchi has stated the following principles: "1. Every rupture of meteorologic equilibrium which produces condensation in rarefaction of vapor, produces a rupture of electric equilibrium. 2. The equilibrium can only be restored by means of a current which is discharged from place to place on the earth's surface. 3. This current cannot fail to act on magnetometers, and to be shown by them." In a recent letter to the Belgian observer, Secchi writes: "I have wished to discuss the observations of recent years, which show a marked diminution of auroras, sun-spots and magnetic variations, and I have always found a decided correspondence, especially in the movements of the bifilar and the vertical. Only, as I should have expected, the excursions were smaller, and we have not had, of late years, those gigantic fluctuations which gave me so much trouble at the time when the observatory was founded. But the variations of the means are so well defined that one can judge the state of the sky by the march of the magnetic instruments. Even when the barometer does not show a great variation, there is always some other element which manifests a distant atmospheric disturbance (change of wind, storm, etc.), especially in summer."—*Ex.* C.

Heat-Conductivity of Metals and Paper.—M. Aymonnet finds: (1) that metals and paper are not, as is generally thought, athermanous; (2) that they are more diathermanous for the obscure radiations from metallic bodies below the temperature of boiling water than for luminous calorific rays; (3) that their absorptive powers are more feeble than those of water; (4) that there is a mathematical relation between the absorbing power of a body and its coefficient of conductibility.—*Les Mondes*, Feb. 22, 1877. C.

India Ink, of a deep black, which gives neutral tints for half-shades, is very rare. It may be made as follows: Rub thoroughly together 8 parts lampblack, 64 parts water, and 4 parts of finely pulverized indigo. Boil until most of the water is evaporated, then add 5 parts gum arabic, 2 parts glue, and 1 part extract of chicory. Boil the mass again till it is thickened to a paste, then shape it in wooden moulds which are rubbed with olive or almond oil.—*Papier-Zeitung*, Feb. 15, 1877. C.

Relation between Viscosity and Temperature.—Silas W. Holman has published an abstract[i] of a paper read before the Amer. Academy of Arts and Sciences, June 14th, 1876. From the results of a number of careful experiments he concludes that the "viscosity of air increases proportionately to the 0·77 power nearly, of the absolute temperature, between 0° and 100° *C.*" The extreme range of his results is from ·738 to ·799. E. Warburg, under date of 9th July, 1876, publishes the results of similar experiments,[ii] both with hydrogen and with air, deducing the exponents between 20° and 100°, ·76 for air (the extremes being ·74 and ·76), and "about $\frac{2}{3}$" for hydrogen (the extremes being ·57 and ·65). The closeness, the narrow range, and the mutual confirmation of these results, obtained nearly simultaneously by two independent investigators, are very interesting. The atmospheric exponents seem to indicate a new analogy between molar and molecular forces. For the viscous particles, so far as they are affected by the same movements, may be compared to the rotating particles of a solid nucleus; the thermal undulations, in a supposed ethereal medium, present a like analogy to the motions of an elastic atmosphere. In a contracting or expanding nebula, the limiting radius between constrained rotation and free revolution varies as the $\frac{3}{2}$ power of the time; the nucleal radius, on account of the law of equal areas, varies as the $\frac{1}{2}$ power of the time. Therefore the nucleal radius varies as the $\frac{3}{4}$ power of the atmospheric radius.[iii] The well-known anomalies, in the elasticity of hydrogen, are in accordance with its low viscosity. Warburg's extremes (hydrogen ·57, air ·76) seem to point towards secondary nucleal and atmospheric relations between air and hydrogen.

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[i] *Lon., Ed. and Dub. Phil. Mag.*, Feb., 1877, p. 81.

[ii] *Pogg. Ann.*, clix, 415.

[iii] *Proc. Am. Phil. Soc.*, xvi, 305 *et al.*

THE METALLURGY AND ASSAYING OF THE PRECIOUS METALS USED IN COINAGE.

[Abstract of the Second Lecture delivered before the Members of the Franklin Institute.]

By ALEXANDER E. OUTERBRIDGE, JR., Assay Department, U. S. Mint, Philadelphia.

ON SILVER.

In my last lecture I traced the history of gold from its earliest mention in the Bible, in the marvelous accounts of the early classic authors, and of the alchemical writers of the middle ages, down to the production of the present day.

Silver was likewise known from the most ancient historic period, and even antedates gold as a medium of exchange. Its frequent mention in Scripture proves its familiar employment among the Jews. The shekel was a silver coin, and as it is very interesting, not only historically, but as revealing the state of coinage in the time of Simon Maccabæus, whose reign began 143 B. C., we will project its image upon the screen by means of the megascope.

On the reverse side you see the budding rod of Aaron, with the legend *Jerushalaim ha-kedoshah* in the Samaritan character, which is, translated, Jerusalem the holy. On the obverse is the pot of manna, with the words *Shekel of Israel.* This is one of the rarest and most remarkable coins in the mint cabinet.[1]

SHEKEL OF SIMON MACCABÆUS.

[1] Several curious old silver coins were used in illustration; among the most interesting were the stater, or 4 drachms of Athens, 2100 years old, showing the sacred owl. The stater of Alexander the Great, B. C. 336—323, showing the head of A. as Hercules with the lion's skin. A silver coin of Sapor, one of the Magian or fire worshiping kings of Persia, preceding the rise of Mohammed, A. D. 300. Denarius of Tiberius, A. D. 14–37, this was the *penny* of the New Testament. A silver coin struck in the time of the Roman Emperor Vespasian, A. D. 69–79, to commemorate the destruction of Jerusalem, with a figure of a weeping woman. And, finally, proof coins of our own mint, for 1877. The slow growth of art and gradual development of mechanical improvements in coinage, were very rapidly demonstrated in this manner.

PHYSICAL AND CHEMICAL PROPERTIES.

We are at once impressed with the brilliant lustre and pure white color of the virgin metal. This property is beautifully shown by the little *granule* of chemically-pure silver reflected on the screen, and magnified to the size of half a ton.

In its malleability and ductility, silver ranks second only to gold. Here is a book of silver leaves. They are so light that they float about on the surface of water, and if I hold some of them over the ascending current of warm air from the register on the floor, they are wafted through the room like thistles in the breeze.

Silver dissolves readily in nitric and in concentrated boiling sulphuric acids. Both of these solvents are used in the mints for the refining of the metal. A great number of re-agents precipitate silver from its solution. We will merely consider a few of the most characteristic and important. This tall jar contains salt water, and here is a silver quarter dissolved in acid; they both form clear solutions. By pouring the silver into the salt we obtain a white, flocculent cloud, falling like a miniature snow shower. The fickle chlorine gas, which was before united with the sodium, forming common salt, has changed partners with the nitric acid, and we have as a result, chloride of silver precipitated and nitrate of soda in solution. This test is of great value in the analysis of silver, and is an exceedingly delicate one, as I shall now endeavor to show you. I am holding in the forceps a tiny particle of silver which weighs just one-hundredth part of a single grain. I put it into a test tube containing a few drops of nitric acid, and it is immediately dissolved. The little glass tank in the lantern, reflected on the screen, contains a common sea-water bath, sufficiently enlarged to make a pretty formidable wave. I now add our drop of nitrate of silver, and I think you can all notice a cloud, the size of a man's hand, forming upon the screen.

Silver melts and volatilizes at a much lower temperature than gold; I place a particle of it on the lower carbon electrode, and you all see the superb emerald-green flame it produces, which is even more beautiful and brilliant than was the vapor of gold.

SOURCES IN NATURE.

Silver is found in the metallic state nearly pure, sometimes in enormous masses, weighing several hundredweight; but it is more frequently combined with other elements, such as sulphur, antimony,

lead, arsenic, etc. The process of extraction from the ore is, therefore, much more complicated than is the case with gold. It is also found over a wider range of geological periods. It occurs in true veins in the older crystalline and metamorphic rocks, in calcareous rocks, and even in the carboniferous period. The large colored geological chart of the world, together with the paintings, will serve to give you a pictorial impression of the natural distribution of the precious metals, and the means adopted for their separation.

My friend, Mr. J. A. Clay, whose valuable cabinet of minerals some of you may have seen, has kindly placed at my disposal his gold and silver specimens; many of these are quite rare, and the megascope will enable you all to appreciate their beauty. Perhaps one of the most remarkable of these is the ruby silver, enclosed in a transparent crystal of quartz.

The most famous mines of the old world are to be found at Kongsberg, in Norway, and at Sala, in Sweden. The silver mines of Spain have been worked from the most remote period by the Phœnicians, Romans and Moors in turn. In fact nearly all the countries of Europe have added their quota to swell the general stock in existence, both of silver and gold.

Mexico formerly produced two-thirds of the product of the whole world. You all remember the famous cake of silver that attracted so much attention in the Mexican Court at the Centennial Exhibition. This cake was afterwards cut up by steam shears, and brought to the mint. It weighed about 4000 pounds, contained $\frac{960}{1000}$ of pure silver, and was worth $68,149.

The famous mines of Potosi, in Bolivia, were discovered in 1545, and were estimated by Humboldt to have produced $1,150,000,000 worth of silver.

Coming now to the United States we find here the greatest mines of the world. Nevada and Colorado are treasure houses of apparently inexhaustible wealth. The presence of veins of silver throughout the territory of Nevada was comparatively unknown until 1859, when the Comstock vein was discovered. "The region was then regarded as an irredeemable wilderness, a land of deserts and death, over which the early pioneers had passed as rapidly as possible in the tide of emigration to the gold regions of California. The scene has changed, Nevada from a comparatively unknown portion of Utah became first a territory and then a state in the Union. The valleys and deserts resound with the shrill whistle of engines and falling of

stamps. The little valleys are brought into cultivation; graded roads are made over apparently impassable mountains; mails arrive and depart daily, and the telegraph connects the business centres with those on the Pacific and Atlantic coasts. All this has resulted chiefly from the discovery of the celebrated Comstock lode, which has already added nearly $80,000,000 in value to the bullion of the world." [1]

In 1876, the Consolidated Virginia mine alone is reported to have yielded 145,666 tons of ore, the value of which was $16,661,940. Colorado yields at the present time a daily average of $15,000 in silver, and $10,000 in gold. The mines of Utah yield a daily average of $12,000 in silver.

REDUCTION OF ORES.

The ancient method of extracting silver from its ores was exceedingly crude, requiring a period of several months in the operation. In the old Mexican process, the ore was ground to a fine powder in circular paved pits or mills called *arrastras*, by means of large stones attached to a shaft drawn round by mules (resembling the manner in which clay is still mixed in some of our brick yards); water was added and the argentiferous mud was piled into heaps and left exposed for a considerable time to the action of the atmosphere. It was then mixed with common salt and copper pyrites called *magistral* by driving mules backward and forward over the mass. Mercury was added which combined with the silver to form amalgam and the dross washed away.

The excess of mercury was removed by squeezing the amalgam in canvas or chamois skin bags. This method is said to have been

[1] "From the Comstock the explorations extended in all directions, and resulted in the discovery of gold and silver bearing veins in most of the principal mountain ranges that traverse the great basin in a general north and south direction. First the metal was traced southward to Esmeralda, Mono, Coso, Walker's River, Owen's River, and the slate range near the southern end of the Sierra Nevada. Eastward the Humboldt mines, Reese River, Goose Creek, Egan Cañon, and Utah Mines, were reached in succession, and the discoveries have been extended eastward to the ranges of the Rocky Mountains, where the prospectors met those of Colorado. Northward in connection with the gold prospectors of Oregon, the precious metals were traced into Idaho, Montana, and British Columbia, and southward, veins have been discovered along the ranges reaching into Arizona, extending the silver region to Sonora, thus connecting the whole with the great metalliferous belt of the Mexican plateau; and with the discoveries of the extreme north, proving a continuous zone of mineral wealth through North America, from Panama to the Arctic Sea."—*Prof. Blake's Report upon the Precious Metals.*

invented in the year 1557 by a miner named Bartholomew de Medina. Nearly all the modern improvements, are merely mechanical modifications of detail, but the advantages of machinery are so great that as much can now be accomplished in a few hours as formerly required several months.

The usual method at present adopted is to roast the silver ores containing sulphur with from six to twelve per cent. of common salt. About 1000 lbs. of ore constitute a charge. The heat volatilizes the sulphur and the chlorine unites with the silver. After the ore has swelled into a spongy condition it is thoroughly sifted and placed in barrels holding 1000 lbs. each, mercury is added and the barrels are revolved for about 20 hours. Modifications of this process are adopted in some cases, to shorten the time; the mercury is sometimes delivered in a fine spray while the ore is kept hot. In order to separate the mercury the amalgam is dried, rolled into balls, and placed in hermetically-sealed retorts. The mercury is driven over and condensed, and the silver is cast into bars (called *pigs*) for shipment. Efforts have been made to effect the removal of the silver without the aid of mercury, and several methods of solution and precipitation have been devised. Ziervogel's process is exceedingly ingenious. The *matt*, consisting of sulphurets of silver, copper and iron, is roasted. The copper and iron first change to sulphates and then to oxyds. The sulphuret of silver also subsequently becomes sulphate, and if the heat were continued would be reduced to the metallic state; as this is not desired, the roasting is discontinued, and the silver is found as a *soluble sulphate*, which is then dissolved in hot water. The silver is precipitated by means of copper plates. The principal objection to this method of reduction is that the presence of certain impurities, such as antimony or arsenic, cause the formation of insoluble salts, which retain a portion of the silver.

Von Patera's process consists in converting the silver into a chloride by roasting with salt. It is then dissolved in a cold dilute solution of hyposulphite of soda. It is next precipitated in the form of sulphide by the addition of polysulphide of sodium, and finally reduced to the metallic state by melting in a furnace while exposed to the atmosphere.

All the processes of solution are comparatively modern, and possess advantages in several ways over the old amalgamation methods.

MINTING.

Silver bullion is received at the mint in the form of bars, pigs, doré silver, old plate and coin. We have even received, in former days, whole altars of silver from Mexico, and Saints innumerable, which were ruthlessly cast into the fiery furnace.

The bullion is frequently rendered exceedingly "short" or brittle by the admixture of base metals. These, of course, require to be eliminated in order to render the metal fit for coinage, and the process is technically called "toughening." The metal is melted in a sand pot with an oxidizing agent, such as nitre, together with a protective covering of borax. The oxygen of the nitrate of potash combines with the base metals, forming volatile oxides; these are partially dissipated and partially dissolved in the borax. The precious metal is then cast into bars, and still another process, known as "parting," is required to separate the silver from the gold. For this purpose the silver deposits containing gold, and the gold deposits containing silver, are melted together so as to make the relative proportions about two pounds of silver to one of gold; formerly three parts of silver were considered necessary; hence the old name, "inquartation." The metal is broken up into *granulations* by pouring it from the melting pot into ice-water; these are placed in large porcelain jars having a capacity of 50 gallons each. Nitric acid is added and steam heat applied for several hours. The silver is converted into a soluble nitrate, and the gold settles to the bottom in the form of brown powder.

By means of a large gold siphon the solution of silver is transferred to a wooden vat containing salt water, having a capacity of 1200 gallons. The precipitated chloride of silver is collected on filters, washed, and reduced to the metallic state by means of granulated zinc and dilute sulphuric acid. Here is another instance of the base inconstancy of the pungent chlorine; having first deserted the sodium for the silver, it already sighs for new elements to conquer, and takes to itself the metal zinc, leaving the silver without a partner. The silver does not now present the beautiful appearance of the virgin metal, but requires purification by the "tryall by fire." It is accordingly pressed into large cakes, dried in an oven at a moderate heat, and melted in large crucibles. It is then cast into fine bars for stamping, or the requisite proportion of $\frac{1}{10}$ of copper is added for coin ingots.

In most of the foreign mints, as well as at the assay office in New York, the parting is effected by means of concentrated boiling sulphuric acid in cast iron kettles. The silver and copper are converted into soluble sulphates, while the gold remains untouched. Sulphurous acid gas is largely developed; this is sometimes conducted into leaden chambers and condensed into sulphuric acid. The silver is then reduced to the metallic state by means of copper plates. The sulphate of copper formed is crystallized in flat pans or vats, and becomes a valuable product. The advantages of this method are in the cheapness of sulphuric acid as compared with nitric, and in the fact that all the copper originally in the alloy is recovered in the form of blue stone, while in the nitric acid process it is lost in the solution of nitrate of soda.

The most recent improvement in refining which seems to combine the three valuable concomitants, of cheapness, simplicity and dispatch, is the *chlorine process* devised by Professor F. Bowyer Miller, of the Sydney Mint, Australia. A current of chlorine gas is passed through the metal while in a molten state; the gas combines with avidity with all the metals except gold, converting the base metals—such as lead, zinc, tin, antimony, etc.—into volatile chlorides, which escape up the chimney. The chlorides of silver and copper being comparatively non-volatile, are retained by a protective covering of melted borax, and, being lighter than the molten gold, they float upon its surface. The pot is then removed from the fire, the gold quickly "sets," and the combined chloride of silver and copper is poured into moulds.

Extended tests of his process were made by Professor Miller at our mint, a few years since, which proved entirely successful. The gold was found to be as nearly pure as by the other methods in use, and the chloride of silver may be reduced in the ordinary way. This ingenious method was devised for the especial purpose of recovering the silver in the native gold of Australia, which often amounts to as much as 14 per cent., but which was formerly lost to the colony, owing to the too great expense of acids in that country.

ASSAYING.

In my first lecture I gave you a brief outline of the method of assaying gold by cupellation. Silver was also formerly assayed in the same way, but it was long known that the result was not quite

accurate, owing to the partial volatility of the metal. Experiments were instituted by the French government, which resulted in the beautiful "volumetric process" devised by Gay Lussac. This is one of the most accurate methods known to chemical science, and so complete was Gay Lussac's original description, that but little room has been left for any improvements, and many thousands of dollars' worth of silver are rapidly and accurately assayed every day in the mint in this way. The rationale of Gay Lussac's method is quite easy to understand, viz., *a given proportion of chlorine will precipitate a definite amount of pure silver.*

We prepare two solutions of common salt water (chloride of sodium), one is known as the "normal solution," the other as the "decimal solution," one begins and the other finishes the assay. Here is a pipette holding just one hundred grammes of the normal solution, which is made of such a strength that it will precipitate exactly one gramme of pure silver. In this bottle, I have a piece of a silver coin of a definite weight, dissolved in nitric acid, and when the pipette charge of normal salt water is added to it, you see the dense white precipitate which permeates the whole liquid. I now agitate the bottle rapidly for a few moments and the precipitate falls to the bottom, leaving a clear solution above. Is any silver still unprecipitated? Let us see. Here is a glass tube with graduated divisions, each division marks one-hundredth the capacity of the large pipette, and here is a solution of salt just one-tenth the strength of the other. I allow the charge of decimal salt water contained in one division of the glass tube to flow over the surface of the silver solution in the bottle, and a cloud is forming on the top. Now, as this charge of salt is $\frac{1}{10}$ *the strength and* $\frac{1}{100}$ *the volume* of the normal solution before added, I know that I have precipitated just $\frac{1}{1000}$ *as much silver*, or one milligramme. The bottle is again agitated until, after four decimal charges have been added, only a very faint *shadow of a cloud* appears, and I am now sure that all the silver is precipitated. A simple rule-of-three sum, gives us the proportion of fine silver in the original weight of alloy.[1] It is not necessary to weigh the precipitate, and even the

[1] The gramme with its decimals is universally adopted by assayers for accurate scientific work, the jewelers' "carat" having been entirely discarded within the last half century. Twenty-four carats represent purity, or 1000 fine. 18 carats mean two-thirds fine or 750-thousandths. Our "standard" for both gold and silver coin is 900 parts of precious metal, and 100 parts of copper; in other words it is nine-tenths fine.

calculation is saved by using Gay Lussac's tables. But perhaps you may think that the strength of the salt solution must vary with changes in the temperature; so it does, but this and other minor sources of error are corrected by testing the strength of the solution every day by means of a "proof assay," made of chemically-pure silver.[1]

SPECTRUM ANALYSIS.

Most of you are, no doubt, familiar with the principles of the captivating study of spectrum analysis. You know that a beam of white light from the sun, or from this powerful electric lamp, is a very complex thing indeed. It is composed of a number of different and distinct rates of vibration of the luminiferous ether, which may reveal themselves to our physical sense of sight as a band of beautiful colors (as in the rainbow), but which are ordinarily so blended together upon the retina that we fail to distinguish the component elements; just as when we listen to a symphony played by a fine orchestra, we appreciate the combined harmonies while we lose the sound of the individual instruments. By inserting this prism in the path of the beam of white light coming from the electric lamp, we can sift out the primary rays, and now we have upon the screen a palette of the purest rainbow colors, spread by nature's own artistic hand, and shading into each other with an exquisite blending far surpassing the fondest dreams of a Titian or a Turner.

STAND, WITH TWO PRISMS.

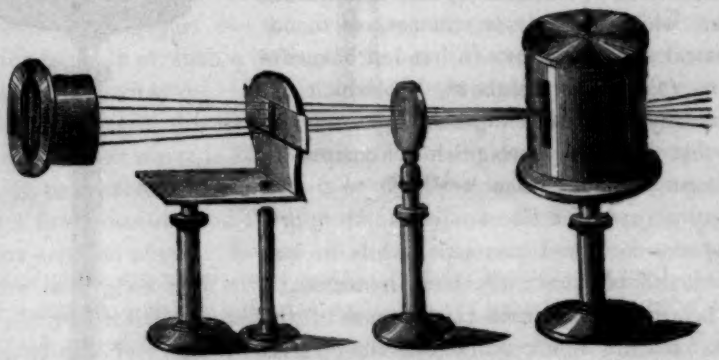
What would be the effect if, in place of this brilliant *chromatic symphony*, we could produce a *luminous solo* by means of a light of a single color?

There is a fundamental mono-chromatic note in the spectrum, which I wish to have as familiar, to your eye, as our national tune is to

[1] Mercury is the only foreign element liable to cause an error in the humid assay. Its presence, even in minute quantity, may be detected by a peculiar haziness in the liquid. A mere trace will prevent the blackening of the chloride of silver in strong sunlight. I believe that this is a fact not generally known.

your ear, for it is the key-note to the whole study of spectroscopic analysis. I therefore place in the electric arc a particle of sodium; this metal is capable of vibrating, when vaporized, at only *one note of color*, and hence you now see upon the screen a single band of intensely yellow light. Please to fix the position of this yellow line in your memory. It is called the "D" line, and is regarded by spectroscopists as a sort of *tuning fork* by which the positions of all the other notes in the chromatic scale are compared. I shall now vaporize a particle of pure gold and pass its light through the prism, ah! there it has *written its signature* upon the screen, in lines of brilliantly colored light, which nature never counterfeits.

Next we will call for the autograph of silver, and you see the beautiful green lines so characteristic of this metal. Then comes



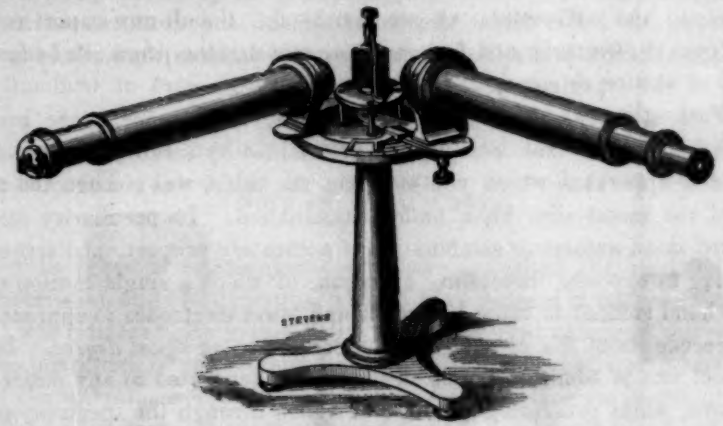
APPARATUS FOR PROJECTION OF SPECTRA.

copper, determined to outshine the others in its bold chirography; and, finally, when we vaporize an alloy of all three metals, we have the signatures of each written without confusion, and endorsed by the infallible authority of nature herself.[1]

We have thus seen that the terrestrial elements (even when alloyed together), in the state of incandescent vapor, write their own distinctive autographs in the spectroscope, whereby each one may be easily recognized. But, you may ask, can these signatures also tell us the relative proportions in which the metals are combined? "Ay, there's the rub." This is the great problem that scientists are trying to solve to-day, and which I hope, and almost believe, we will

[1] By plugging the metal firmly into the cavity in the lower carbon, and filing it down to a cone, thus forcing the current to pass constantly from the molten globule, an uninterrupted spectrum was obtained in each experiment.

yet see accomplished. A step in this direction, which seemed to promise hope of success, was made some time ago by Mr. J. Norman Lockyer, the English astronomer. You know that when powerful electric sparks (from an induction coil) are passed between two terminal points of metal to be examined, a small portion of the metal is vaporized; its spectrum is then examined through an instrument of this kind.



SPECTROSCOPE.

Mr. Lockyer noticed while studying these luminous autographs, that when he separated the metallic electrodes, causing the spark to leap a greater distance through the air, the spectral lines no longer continued to cross the entire field of vision, but certain of them broke in the middle; and upon further increasing the distance between the electrodes, the hiatuses in the spectral lines increased proportionately, but unequally with different alloys. Upon this discovery Mr. Lockyer based the theory of a possible quantitative analysis.

The spectroscope was known to be marvelously sensitive to the impression of these autographs, and it therefore appeared plain that could such a method of analysis be reduced to a practical basis, its value would be immense in assaying metals used in coinage. For although the present modes of assaying precious metals have been brought to great perfection, yet the process is slow and tedious, requiring many chemical operations and great delicacy of manipulation; and "there is something captivating in the idea of a determination, as it were, by a flash of lightning, or in the twinkling of an eye, what proportion of gold or silver is present in any bar or coin."

It was with the hope of reducing this beautiful theory to practice that I undertook, with the approbation of the chief assayer of the mint, an extended investigation in the assay laboratory, a portion of the work being performed at the University of Pennsylvania with the excellent apparatus and appliances afforded in the new college building. As the result of this investigation was published in the form of a report to the assayer, in the *Proceedings of the American Philosophical Society*, and afterwards as an article for the JOURNAL OF THE FRANKLIN INSTITUTE, it is unnecessary to do more than allude to a few of the experiments.

Various grades of alloys of gold, silver, and copper, were prepared, and their exact composition determined by careful assays. A special apparatus which you see upon the table, was constructed to hold the metal slips when under examination. Its peculiarity consisted in an automatic combination of accurately proportioned screws acting in opposite directions, by means of which a single motion of the hand sufficed to cause the upper and lower electrodes to approach or recede from the central line of contact in *an equal degree*. Its object was to admit of the electrodes being separated to any desired extent, while preserving the line of vision through the spectroscope directed to the centre of the spark. I found that while a decided difference in the spectral lines could be observed between alloys of comparatively wide variation, I was unable to detect any appreciable distinction between those varying but slightly in their composition. Several curious and unexpected anomalies were noticed in the course of this investigation, but the principal source of difficulty appeared to be owing to the infinitesimal amount of metal vaporized by the spark. I found, for instance, that when small electrodes were accurately weighed upon the delicate assay balance a thousand sparks might be passed between these points, each spark producing a brilliant spectrum of the metal, and yet the total loss in weight was only one-thousandth part of a grain; that is to say, each spark vaporized one-millionth part of a grain! Now, as I have already shown you, it is necessary to determine assays of the precious metals to the one-ten thousandth part of the normal assay weight, and it is hardly conceivable that a discrimination to the one-ten thousandth part of the *spark* assay weight or the *one-ten billionth* of a grain is practically possible. Even if it were so, the present state of metallurgy is not sufficiently perfected to enable us to mix the alloy so homogeneously

that we could safely assume that a test on such an atomic scale would correctly represent the value of a large deposit.

While there are several apparent paradoxes which have not as yet been explained, judging by former experiences in which even more mysterious problems have been resolved by study, we are surely warranted in anticipating, that when a larger number of observations, to be made, perhaps, by many experimenters, shall have been collated, the true scent may suddenly be struck, which shall discover the desideratum of quantitative spectroscopic analysis of metallic alloys.

CALORIFIC INTENSITY OF SOLAR RAYS.

Note of M. A. Crova.

"In previous communications,[1] I have indicated the methods of observation and of calculation, which I have adopted in my researches. It was interesting to inquire what are, at different epochs of the year, the quantities of heat received during a day by the horizontal surface of the soil; these determinations may excite an interest in the study of the phenomena of vegetation, and furnish facts for the study of the propagation of solar heat in the earth. With this aim, I have calculated the observations made during two normal days, during which the sun shone without interruption, days remarkable for the continuity of the atmospheric diathermaneity, and chosen as near as possible, the one to the winter solstice, the other to the summer solstice.

"I have already given[2] the measurements of calorific intensity in the solar rays, made at Montpellier during the 4th of January, 1876. This series was remarkable for the clearness of the sky and the general symmetry of the hourly curve of calorific intensities. The total quantity of heat received during the whole day, normally to the direction of the solar rays, upon a surface of 1 sq. centimetre, could be obtained by integrating the hourly curve, but it is more simple and equally precise to trace the hourly curve of the calories from sunrise till sunset, and to *weigh* the area of the curve thus obtained. If the paper is of uniform thickness, the weight of this area, compared with the weight of the rectangle in which it is inscribed, will give the

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[1] *Comptes Rendus*, lxxxi, p. 1205, and lxxxii, pp. 81 and 375.

[2] *Memoires de l'Acad. des Sciences et Lettres de Montpellier*, 1876, p. 61.

total value of the calories received in this interval, normally to the sun's rays; by previously weighing rectangles of different surfaces, from the paper which I used, I assured myself of the proportionality of their surfaces to their weights.

"On the other hand, I traced upon the same paper the curve which gives, for each observation, the product of the calorific intensity of solar radiation by the cosine of the sun's zenith distance at the middle of the observation; the weight of this curve measures the total heat received by 1 sq. centimetre of the horizontal surface of the soil, from the moment of sunrise till that of sunset.

"I made a complete series of observations on the 11th of July, 1876, near the shore of Palavas, 12 kilometres from Montpellier; this day was remarkable for the clearness of the sky, and the steadiness of a light northwest wind that weakened the disturbing influence of the sea breeze, which was not perceptible at the surface of the ground. The horizon being free in all directions, I was able to measure, without interruption, from sunrise to sunset, by means of two actinometers carefully compared and simultaneously observed, the calorific intensity of the direct radiation, and that of the part which was transmitted through a layer of water 1 centimetre thick.

"The observations of July 11th show the want of symmetry peculiar to summer days; after weighing the hourly curves of the morning and evening calories, and doing the same for the curves of the products of calorific intensities by the cosine of sun's zenith distance, I calculated the total value of the quantities of heat received during this day, normally to the solar rays and by the horizontal surface of the soil, upon an area of 1 sq. centimetre. The results of these measurements for the two days are as follows:

"JANUARY 4TH, 1876.

	Heat received on 1 sq. centimetre.	
	Normally.	On the surface of the soil.
1. From sunrise till noon,	264·4	78·9
2. From noon till sunset,	270·6	82·3
3. From sunrise till sunset,	535·0	161·2

"The calories received normally varied between 0 and 1·29, in 9 hours of exposure.

"The calories received on the earth's surface varied between 0 and 0·53, in 9 hours of exposure.

"The heat received on the earth's surface, is ·301 of the normal heat.

"JULY 11TH, 1876.

	Heat received on 1 sq. centimetre.	
	Normally.	On the surface of the soil.
1. From sunrise till noon,	451·5	293·5
2. From noon till sunset,	424·9	280·6
3. From sunrise till sunset,	876·4	574·1

"The calories received normally varied between 0 and 1·21, in 15 hours of exposure.

"The calories received on the earth's surface varied between 0 and 1·10, in 15 hours of exposure.

"The heat received on the earth's surface, is ·655 of the normal heat.

"The heat received normally on Jan. 4th, is ·610 of that received on July 11th.

"The heat received on the earth's surface on Jan. 4th, is ·281 of that received on July 11th.

"These results give a precise measure of the irregularities produced, in summer and in winter, by the obliquity of the solar rays, and by the duration of the sun's appearance above the horizon, between the absolute values of the intensity of solar radiation, and between the ratios of the quantity of heat sent directly, to that which is received upon the horizontal surface of the soil."—*Comptes Rendus*, March 12th, 1877. C.

Academy of Natural Sciences.—Part III of the Proceedings, for 1876, contains: Self-fertilization in Mentzelia ornata, *Meehan;* Direct Growth Force in Roots, *Id.;* Interpretation of varying forms, *Id.;* On the Marine Faunal Regions of the North Pacific; An Introductory Note to the Report on Alaskan Hydroids, by Mr. Clark, *Dall;* Report on the Hydroids collected on the coast of Alaska and the Aleutian Islands, by W. H. Dall, U. S. Coast Survey, and party, from 1871 to 1874, inclusive, *Clark;* On the Extension of the Seminal Products in Limpets, with some remarks on the Phyllogeny of the Docoglossa, *Dall;* Descriptions of some vertebrate remains from the Fort Union Beds of Montana, *Cope;* On Conglomerate No. XII, *Young;* The Australians, *Pickering;* On Sonomaite, *Goldsmith;* Explorations in S. America, *Cope;* On Boussingaultite and other minerals from Sonoma County, *Goldsmith;* Report on Insects introduced

by means of the International Exhibition, announcing "with moderate certainty, that no evil results will occur to our agricultural interests, from any introduction of foreign insects, by means of the Centennial Exhibits," *Le Conte*, chairman; Notes on a Cirripede of the California Miocene, with remarks on Fossil Shells, *Conrad;* Notes on American Cretaceous Fossils, with descriptions of some new species, *Gabb;* On Ozocerite, *Leidy;* On Hyraceum, *Id.;* On Itacolumite, describing specimens "reported to be from Mariposa Co., Cal., which are interesting and worthy of note by reason of the new locality, and as showing the peculiarities of this kind of sandstone in a marked degree," *Blake;* Mineralogical Notes, *Willcox;* Impurities in Drinking Water, stating that "during the last eight years, whenever the Schuylkill has been covered with ice, he observed that the water supplied by the city possessed a disagreeable odor and taste like chlorine," *Id.;* On Excrescences and Eccentric Wood Growths in the Trunks of Trees, showing that "there was no reason why cells, predestined, under ordinary circumstances, to be merely bark cells, in their change from wood cells should not occasionally retain enough of growth force to carry on a feeble wood constructing system of their own," *Meehan;* Pickeringite from Colorado, *Goldsmith;* Epsomite on Brick Walls, accounting for the whitish incrustation at the beginning of winter, *Id.;* Notes on Fishes from the Isthmus of Panama, *Gill;* On some Extinct Reptiles and Batrachia from the Judith River and Fox Hills Beds of Montana, *Cope;* Our Sidereal System, and the Direction and Distance to its centre, *Ennis.* C.

Prize for a method of Detecting Adulterations of Butter.—The bureau of the LeipzigPharmaceutical Union, offers a prize of 300 marks for the discovery of a sure and practical method for the detection of adulteration of butter by other fatty substances. Professors Dr. Heintz, in Halle, and Dr. Knop, in Leipzig, have consented to act with Herr Kohlmann as judges in awarding the prize. Each competing essay is to be provided with a motto and accompanied by a sealed note, containing the motto on the outside and the author's name on the inside, and both are to be forwarded to Herr Kohlmann, Apothecary, in Leipzig-Reudnitz, before September 30th, 1877.—*Dingler's Polyt. Jour.*, 223, 2, Jan., 1877. C.

ORNAMENTAL IRON WORK.

[Abstract of the second lecture in Prof. Pliny E. Chase's course, on "Lessons of the Centennial," delivered before the Franklin Institute, March 13th, 1877.]

The earliest historical reference to iron is found in Genesis, iv, 22. "Tubal Cain, an instructor of every artificer in brass and iron," lived, according to Biblical chronology, about 3700 B.C. He is supposed by many, and with good reason, to have been the same as Vulcan. He was not merely a smith, but he was an ornamental iron worker, "an instructor of every artificer." The Hebrew word *khoresh*, "artificer; cutting instrument," is akin to *kheresh*, "cunning worker;" both being derived from *kharash*, "to cut, carve, engrave, sculpture." Among other Biblical allusions we may note "an instrument of iron," Num., xxxv, 16; the giant Og's "bedstead of iron," Deut., iii, 11; "chariots of iron," Josh., xvii, 16; "saws, harrows of iron and axes of iron," 2 Sam., xii, 31; "chains and fetters of iron," Ps., cxlix, 8; "an iron pillar," Jer., i, 18.

Some doubts have been expressed whether Homer knew anything of iron, but Hesiod, who, according to Herodotus, was a contemporary of Homer, speaks of the "iron age," and the iron money of Lycurgus was in circulation about 850 B. C. Notwithstanding the interference of rust with the preservation of iron work, iron hatchets have been found in the Etruscan tombs; an iron forge, tools and nails among the lake dwellings of Switzerland; and iron pillars are still standing in India, which are supposed to be more than 1500 years old. Rings, both of gold and of iron, circulated as money in Britain, at the time of the Roman conquest, but they were probably imported. Iron works were in active operation upon the island, A. D. 120.

The peculiar combination of carbon with iron, which we call steel, and the art of tempering, seem to have been known in prehistoric times. At the beginning of the Christian era the best steel was imported into Rome from China, that of Parthia being of inferior quality. Steel armor was in common use among the soldiers of William the Conqueror. Steel was manufactured in Sweden as early as A. D. 1340, but the art of fusing steel in a crucible, and then casting it into bars so as to form a homogeneous "cast steel," was invented at Sheffield in 1750, and was long kept secret. Bessemer steel is pre-

pared by forcing a powerful current of air through a quantity of melted iron. The oxygen of the air, uniting with the carbon and silicon and other impurities of the iron, produces a rapid combustion and intense heat. The blast is continued until the carbon is nearly all consumed, when an alloy called "ferro-manganese" is added, in such proportions as are needed to re-carbonize the metal and produce such "low" or "high" grade of steel as may be required. The largest present use of Bessemer metal is in the manufacture of steel rails of a "low" grade, combining great tenacity and durability, with slight brittleness and feeble tempering properties. The bends and twists and cuts and tensile tests, of the specimens on the table, show how admirably this material is fitted for artistic ornamental treatment.

The art of casting iron seems to be quite a modern one, but the date of its invention is uncertain. There is a cast iron grave-slab in Sussex, Eng., made about A. D. 1350. A minute proportion of phosphorus, which renders iron wholly unfit for the Bessemer process, adds greatly to its fluidity, as is shown by the remarkably sharp and beautiful ornamental castings in Berlin iron. The Centennial display, by American iron founders, of cast statuary, vases, railings, bronzed and enameled work, stoves, grates, etc., showed a taste of design and care of execution worthy of almost unqualified praise. The architectural combination of cast and wrought iron, in the structure of the main building, also produced many pleasing and commendable effects. But there seems to have been little thought of the admirable results which might be reached, by a treatment similar to that of the best Japanese bronzes; the casting being regarded merely as a convenient way of forming a mass which can be more readily cut into shape than a larger piece of metal.

Both cast and wrought iron admirably illustrate the importance of the great natural principle of oscillation or vibration. It is now commonly believed that no two material particles are in absolute contact, but that, even in the most solid substances, there are continual internal tremors and orbital motions, much more complicated than those which keep the planets and "stars in their courses," and yet governed by similar laws. In consequence of such internal motions, glaciers and rocks and metals can be made to "flow," not only through the intervention of the fiery fingers of heat and flame, but also by simple continuous pressure. M. Tresca, who has studied the subject very carefully, is unable to find any limit between the fluid

and the solid conditions of matter. There are merely differences of viscosity, analogous to that between water and molasses. By means of this flow, iron and many other metals may be rolled into sheets, drawn into rods or wires, or hammered into various desired shapes by skilful workmen. Here is a core-chuck, which can be put into a turning lathe, for shaping a flat disk of metal into a hollow vessel. As the chuck revolves, a gentle steady pressure causes the flowing particles to adjust themselves to its sides, so that, by having proper cores, we can "spin" bowls, vases, teapots, creamers, and various useful or ornamental dishes with great rapidity.

After the vessel is spun, it may be prepared for ornamenting by vibrations and flow of another kind. You remember the beautiful "repoussé" work in many of the departments of the Exhibition, and some of you, doubtless, were curious enough to inquire how it was made. The old method was by simple, careful hammering from the back; but there was always danger of an unlucky blow, that would break the metal and ruin the work of many days or months. Here is a "snarling," or repoussé[1] iron, firmly fastened in a vice. Mr. Krider has kindly sent us one of his skilful workmen, who will show us the process of snarling. The floral or other design is drawn on the outside of the vessel, and you see that when Mr. Sloan hammers on the end of the snarler which is nearest the vice, the whole tool is set in vibration, and the rapid, gentle taps of the other end gradually raise a knot or snarl of the desired height and outline. After the snarling or repoussé work is done, the chasing process follows. The hollow is filled, as you observe, with a softish cement, which yields slightly to the pressure of the chisel or graver, or such other tool as the artist may select from this large assortment, and the design is thus wrought out into the beautifully finished details of stem and leaf, stamen and petal, and tendril and delicate veining.

Iron is fitted by its cheapness, strength, elasticity, malleability, ductility and plasticity, for general application to ornamental uses and for taking expressions in tracing and foliage such as no other material can supply. The processes which I have just explained, furnish an immense addition to the facilities of the artisan for the

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[1] The terms "spinning" and "snarling" seem to have been borrowed from the textile arts. The French word "repoussé," signifies "pushed back," indicating the mode of hammering.

expression of his thoughts, and make it the more wonderful, as well as the more deplorable, that the æsthetic treatment of wrought iron and steel should have become so nearly a lost art. In all parts of Europe there are many mediæval specimens of such treatment preserved, which are worthy of special study. Candelabra, grilles, railings, newels, balusters, crosses, brackets and rings for cornice poles, chapel screens, gargoyles, vanes, bolts, hinges, locks, keys and escutcheons, knockers, handles and rings for bells and doors, are decorated with *eisen-blumen* or flower-work of beaten iron, or with various tracery, both serious and grotesque. They display an exuberance of invention and judicious taste which are calculated to enhance our respect for the earnestness and thoughtfulness of the unknown workmen, whose resounding hammers so lastingly imprinted lessons of faith, hope and love.

In Germany, Bohemia, Switzerland, and especially in the Tyrol, men in armor, bears or other animals, skilfully wrought, and holding the flag of the district or canton, are often found in the public squares or market places. At Jensbach there are remains of ancient smelting works, and of a forge which seemed specially devoted to a peculiar symbolic teaching. The great gray stone houses of the village are adorned by emblems of love and social feeling, being nearly all protected by curious huge dolphins, which are, apparently, just on the point of flitting from the water-spouts. In nearly every village church or graveyard the artistic eye may be gratified by contemplating the taste displayed in a cross, or a rood screen, or an altar-gate, or a chandelier, or the ridge-cresting and terminals which wed the gothic architecture to the sky and landscape, as if with a fringed network of delicate lace on the delicate gray, and against the blue. Sometimes the rods of the screen are so arranged in perspective as to represent an iron-arched arbor, under which one must walk in traversing the length of the aisles. Sometimes the symbolism is made still more expressive by combining rich clustering vines with the intricate blossoms of passion flowers, displaying a wealth of tendrils and leaves naturally and gracefully entwining the palings of a simple or rustic gate; always the evidences of devout aspiration, childlike trust, deep feeling and loving labor, are such as to bring us into a reverent sympathy with the artists who sought to give visible utterance to some of the most universal and most far-reaching longings of humanity.

Near the west door of the Antwerp Cathedral is a well with gothic canopy and tracery of iron, surmounted by the statue of a knight in armor. It was executed, in 1480, by Quentin Matsys, "at one time a blacksmith, afterwards a famous painter," whose romantic history is briefly commemorated by the inscription on a neighboring tablet: "Connubialis Amor de Mulcebre fecit Apellem"—connubial love made an Apelles from a Vulcan. It is said, that this first "learned blacksmith" fell in love with a painter's daughter, and in order to obtain her for his bride he changed his profession, acquiring even greater reputation as a colorist than he had gained by his handiwork at the forge. In the knowledge of that universal language which rings so sweetly in the ears of youthful admirers, he set a precedent for the learned blacksmith of our own days; but, unlike his far-famed successor, he manifested no disposition to trace the universal language into all its dialects. His parity of success in his two vocations, shows that he had the fire of true artistic genius, and his fame may encourage the wielder of the hammer, as well as the sitter at the easel, to look for an ever-ready appreciation of whatever depth of thought finds expression through patient, faithful work.

It is a quarter of a century since the first London "World's Fair" revived a European interest in the capabilities of wrought iron for artistic uses. The progress of the revival is most strikingly exemplified in the Oxford Museum, which was erected in 1867, but traces of it are to be seen in all directions, about the modern public and private edifices of Great Britain, as well as in many of the churches. A notable example of good ecclesiastical work is the Hereford Cathedral Screen, which was shown in the International Exhibition of 1862, before it was removed to the place for which it was designed. Dr. Dresser speaks of it as one of the finest examples of artistic work with which he is acquainted. The grilles, altar-rail standards, and English fire-dogs, in the present Loan Exhibition of the Pennsylvania Museum and School of Industrial Art, placed, as they are, beside a pair of ornamental Florentine andirons of the 16th century, show that neither good taste nor skilful execution are wanting in the smiths of our day, and that an educated demand will call out work which may challenge comparison with anything mediæval. The pagoda-like pavilion of Messrs. Hart, Son, Peard & Co., with its great variety of contents, cast, woven, or hammered into "joys forever," justly claimed a large share of attention from the visitors

to the Main Exhibition Building, and in the Belgian department, Prosper Schroyer's door, with its wrought iron vines, grapes, and bunches of climbing flowers, furnished more food for thoughtful study than the rich laces and costly embroideries which surrounded it.

Our own city already shows the effects of the revival, but, unfortunately, our most satisfactory ornamentation is imported. The magnitude and importance of the iron and steel interests in the Keystone State, should stimulate our ornamental designers, architects, and contractors, to a generous rivalry with their European brethren. Elkington's Helicon Shield showed admirable effects from working steel with other metals by "appliqué," inlaying, and repoussé; the Spanish, Moorish and Indian departments contained much successful punching, pressing, and damaskeening; the Russian electrotypes in iron, by the Jacoby process, gave a delicate surface-finish which might be often used artistically with great advantage; the plasticity of steel, through its capabilities of alternate softening and hardening, and the elasticity of its graceful shapes when finally and permanently tempered, were everywhere full of suggestiveness. Shields, suits of armor, weapons of war, knives, kettles, steel and iron jewelry, and other articles of personal or household decoration, were well represented, most of them adorned with traditional and conventional embellishments which have been handed down from a remote antiquity. Let our wise designers study such examples; let them cleverly combine the different ways of working and different styles of ornature; let them learn from the worker in bronze, the goldsmith, and the jeweler, new devices to charm the eye and elevate the imagination; and their field of labor will be so much enlarged that they will seem to have invented a new industry.

I have spoken of the symbolical thought which was so generally expressed by the iron-workers of the cinque-cento. How can it be better revived and expanded than by taking lessons from the old schoolmasters of Eastern Asia, "these from the land of Sinim?" The gipsy kettle, as it is often called, the common bulged tripod dinner-pot, which is used the world over, is copied from Chinese incense-burners that were in use more than five thousand years ago. The Chinese have long had a mania for collecting old bells and vases, partly from their universal reverence for antiquity, partly for the severe simplicity of outline and garniture by which the articles are generally characterized, partly for their moral lessons and associations.

A motto from Confucius, or a line of wise advice from some other favorite author, is commonly cast, stamped, or cut into the bronze; the "all-seeing eye," under various modes of conventional treatment, looks from the outer surface, even as it looks from the amulets and edifices of Egypt and Yucatan; the three feet are said to represent the three guardian spirits that watch over the Emperor, the nobles, and the people. Nearly all the old metallic vases have a special history, independent of their antiquity, for it has been a practice from time immemorial, to use them as presents from princes and nobles, and men of wealth or station, to those whom they wished to honor. In the magnificent and unique collections of cloisonné enamels which adorned our Centennial, the delicate filigree, and the richly variegated hues of the cellular glazing, seemed to be lavished with a peculiarly loving tenderness, on the old homely and homelike form which we all know so well. Our workmen enamel iron skilfully for common purposes; who doubts that they might rival their almond-eyed brethren in applying the art to æsthetic purposes, if they were rightly encouraged? Any ornamentation upon articles of daily use, especially if it be symbolic, or otherwise suggestive of high ideals, may become a source of continual gratification and of constant ennobling instruction.

I can think of no decorative process that has ever been employed upon any metal, which is not equally suited for iron; indeed I doubt whether there is one which has not been repeatedly and successfully tried upon that most precious metal. A judicious renaissance may lend new force to the Jewish legend which has been so well illustrated, by Schuessele with his brush, and by Sartain with his burin. The story runs, that when the temple was finished, Solomon gave a feast to his artificers. On unveiling the throne, a blacksmith was found in the seat of honor, on the right of the king's place. The people clamored, and the guards wished to cut him down, but Solomon commanding him to speak, he said: "Thou hast, O king, invited all craftsmen but me, yet how could these builders have raised the temple without the tools I furnished?" "True," answered Solomon, "the seat is his of right. All honor to the iron-worker."

[The lecture was illustrated by practical repoussé working, chasing, and lantern pictures of Centennial exhibits, furnished by the Centennial Photograph Company.]